

BETTESWORTH's

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NAVAL MATHEMATICS:

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P R A C T I C A L R U L E S
O F T H E
A R T O F N A V I G A T I O N.

INTENDED FOR THE
USE of SCHOOLS, and YOUNG MARINERS.

By J. BETTESWORTH, *K*

MASTER of the NAVAL ACADEMY, CHELSEA.

L O N D O N:

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P R E F A C E.

TH E natural situation of England as a commercial country, the flourishing state of its manufactories and trade, and the high estimation in which it is held for its sciences, hath always, and ever will, render it a pattern to others for the Theory and Practice of NAVIGATION.

The Writers on this Science have been numerous; and although it seemed to be well understood many ages past, yet their labors may be viewed as a continual chain of improvements.

The only object of the Author of this little Treatise, is to simplify Navigation, and to lay down such plain and easy Rules for putting it in Practice, as from his experience in teaching the Science, he hath found eminently useful.

The

The custom that hath prevailed amongst Writers on this Subject, of annexing Tables to their own Work the Author judges highly improper, as being an unnecessary repetition of a laborious Work, at the hazard of a multitude of Errors; those published with such peculiar attention and care, by order of the Commissioners of Longitude, being all that are necessary for the Astronomical part of Navigation; and the *two* which are wanted for keeping a Ship's reckoning, viz. one of Meridional Parts, and the other of the Difference of Latitude and Departure, I have the authority to Announce soon to be published in a most ample Manner.

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COMPOUND ADDITION, SUBTRACTION, &c. OF MOTION and TIME.

OF MOTION.

DEFINITION.

Motion is reckoned in parts of a great circle of the sphere, and is divided into signs, degrees, minutes, and seconds, &c. every great circle containing 360 degrees of 12 signs, each sign being 30 degrees, each degree 60 minutes, each minute 60 seconds, &c.

ADDITION.

To add together degrees, minutes, seconds, &c.

R U L E.

Place degrees under degrees, minutes under minutes, &c. and then begin to add the lowest denomination; if seconds, find how many minutes they make, so many

B

you

you carry to the minutes, the overplus, if any, place under the seconds; this must be well observed in placing the overplus under the minutes, degrees &c. Then add up the minutes, and find how many degrees they make, the number of which carry to the degrees; and in like manner add up the degrees, and find how many signs, &c. proceeding in the same manner through the whole.

	s	o	'	"		s	o	'	"		s	o	'	"
To	o	23	19	47		4	24	17	49		11	29	53	14
Add	o	29	44	37		5	19	11	31		10	24	49	36
Sum	1	23	4	24		7	23	49	47		7	24	10	53
<i>The Work.</i>						6	19	9	42		9	14	45	29
84" =	1'	24"				4	20	39	40		4	23	11	46
64' =	1°	4'				7	27	50	59		8	19	41	2
53° =	1 ^s	23°												

S U B T R A C T I O N.

To Subtract signs, degrees. &c.

R U L E.

When the lower number is greater than the top, 60 must be borrowed in the place of minutes and seconds, which add to the seconds or minutes and then subtract. You borrow 30 in the degrees and 12 in the signs, when greater than the top number; observing to add one to the next number through the whole, whenever you borrow.

From 27

(3)

	s	o	'	"
From	27	19	4	
Take	13	30	9	
Remains	13	40	55	

Work.

$4 + 60 - 9 = 55$
 $19 + 60 - 38 + 1 = 40$
 $27 - 13 + 1 = 13$

	s	o	'	"
From	11	24	12	19
Take	4	29	14	41

	cir	s	o	'	"
From	1	3	9	34	52
Take	0	7	19	46	59

MULTIPLICATION.

C A S E III.

When the Multiplier does not exceed 12

R U L E.

Begin to multiply at the lowest denomination, if seconds find how many minutes they make, so many you carry to the minutes, and the overplus, if any, place under the seconds; then proceed in like manner as the rule of Addition directs, multiplying instead of adding.

	s	o	'	"
Mul.	3	17	53	29
			4	
Pro.	1	2	11	33
			56	

	s	o	'	"
Mul.	7	29	49	54
			7	

B 2

Work.

(4)

Work.

$$29'' \times 4 = 116'' = 1' 56''$$

$$53' \times 4 + 1' = 213 = 3^{\circ} 33'$$

$$17^{\circ} \times 4 + 3 = 71^{\circ} = 25 \ 11^{\circ}$$

$$3^s \times 4 + 2 = 14^s = 1c \ 2^s$$

<i>s</i>	<i>o</i>	<i>'</i>	<i>''</i>	
Mul,	11	27	57	33 by 12
			12	

C A S E II.

When the Multiplier exceeds 12

R U L E.

Multiply by numbers, which, when multiplied together make the Multiplier, or as near as possible: but when those numbers are less than the Multiplier, by what it wants, multiply the multiplicand, and add its product to the last product; and when these numbers are more than the Multiplier, by what it may be more multiply the multiplicand, and subtract its product from the last product.

<i>c</i>	<i>s</i>	<i>o</i>	<i>'</i>	<i>''</i>	
Mul.	0	4	16	43	47 by 25
				5	$5 \times 5 = 25$
	1	10	23	38	$55 = 5$
				5	

Pro. 9 5 28 14 35 = 25

<i>s</i>	<i>o</i>	<i>'</i>	<i>''</i>	
Mul.	8	24	57	55 by 37

<i>c</i>	<i>s</i>	<i>o</i>	<i>'</i>	<i>''</i>	
Pro.	27	2	23	42	55

Fin
denom
multip
one of
the left
denom

Divide

7

Multip

Proof

(5)

^s ^o ⁱ ^{''}
 Mul. 11 19 37 42 by 59
 Pro. 57 3 18 4 18

^c ^s ^o ⁱ ^{''}
 Mul. 5 5 25 40 36 by 252
^c ^s ^o ⁱ ^{''}
 Pro. 1302.11 20 31 12

D I V I S I O N.

C A S E Ist.

When the Divisor is not greater than 12.

R U L E.

Find how often the Divisor is contained in the greatest denomination of the dividend, and the remainder, if any, multiply by as many of the next denomination, as make one of the next greater, adding in the given number of the lesser and divide as before, 'till you come to the lowest denomination the Question is given in.

^s ^o ⁱ ^{''} Divide 9 19 37 57 by 7	^c ^s ^o ⁱ ^{''} Div. 4 6 29 57 51 by 11
7) 9 19 37 57	11) 4 6 29 57 51
1 11 22 33 6 over	0 4 29 59 48 3 over
Multiplied by 7	Multiplied by 11
Proof 9 19 37 57	Proof 4 6 29 57 51

B 3

Work

Work of the first Example.

$$\begin{array}{r} 7 \overline{) 9^s} \\ \hline \end{array}$$

$$1-2$$

$$3^0$$

$$7 \overline{) 79^0} = 2^s + 19^0$$

$$11-2$$

$$6^0$$

$$7 \overline{) 157'} = 2^0 + 37'$$

$$22-3$$

$$6^0$$

$$7 \overline{) 237''} = 3' + 57''$$

$$33 \quad 6$$

$$\begin{array}{r} \text{c} \quad \text{s} \quad \text{o} \quad \text{i} \quad \text{''} \\ \text{Divide } 5 \quad 3 \quad 0 \quad 52 \quad 54 \text{ by } 9 \end{array}$$

Quotient

$$\begin{array}{r} \text{c} \quad \text{s} \quad \text{o} \quad \text{i} \quad \text{''} \\ \text{Divide } 7 \quad 2 \quad 7 \quad 1 \quad 12 \text{ by } 12 \end{array}$$

Quotient

C A S E II^d.*When the Divisor is greater or more than 12*

R U L E.

Divide by long Division, observing well the rule in case 1st.

$$\begin{array}{r} \text{c} \quad \text{s} \quad \text{o} \quad \text{i} \quad \text{''} \\ \text{Divide } 11 \quad 10 \quad 24 \quad 49 \quad 24 \text{ by } 39 \end{array}$$

(7)

$$\begin{array}{r} \text{c s o i n c} \\ 39) 11 \ 10 \ 24 \ 49 \ 24 \ (^{\circ} \\ \underline{12} \end{array}$$

$$39) \begin{array}{r} 142 \\ 117 \end{array} (3^s$$

25^s

3^o

$$39) 774^{\circ} (19^{\circ}$$

384

35^r

33

60

$$39) \begin{array}{r} 2029 \\ 195 \end{array} (52'$$

79

78

1

60

$$39) \begin{array}{r} 84 \\ 78 \end{array} (2$$

6

c s o i n
Div. 174 9 19 54 52 by 124

c s o i n
Facit 1 4 27 29 57

Facit of 3^s 19^o 52' 2"

OR

O F T I M E

DEFINITIONS and PRINCIPLES.

1st. Time is of two kinds, viz. Civil and Astronomical; Civil is that which is in common use, and the day begins at midnight, or 12 hours sooner than the Astronomical day, which begins at noon; this last is always used at sea, and reckoned to 24 hours, or from noon to noon.

2d. Ante Meridiem is the time from midnight to noon, and is marked A. M.

3d. Post Meridiem is the time from noon to midnight, and is marked P. M.

4th. The Civil and Astronomical day agree from noon to midnight, but from midnight to noon the Civil time is reckoned 12 hours too much, therefore, 12 hours subtracted from the Civil time, gives the Astronomical time; thus, the 5th, of August, at 7 hours A. M. Civil time, will be the 4th, of August, and 19 hours Astronomical time; and Aug. 10, at 11 A. M. will be Aug. 9, and 23 hours &c. &c.

A GENERAL RULE to be observed in performing Addition, Subtraction, Multiplication and Division of Time, is viz. it must be done in like manner as the rules given in Motion, observing well that Time is divided into years, months, weeks, days, hours, minutes, seconds, thirds, &c. but the least denomination in use is seconds, of which 60 make a minute, 60 minutes one hour, 24 hours one day, 7 days one week, 4 weeks one month, 12 months one year; more properly 365 days, 5 hours, 48 minutes, make one year.

N. B. Compound Addition, Subtraction. Multiplication and Division, of any kind whatever, that is of money, Troy-weight, &c. must be performed in the same manner as the rules given in Motion, only observing the different Tables.

To
Add

Y

5

4

5

7

From
Take
Rema
Proof

From
Take
Rema
Proof

A D D I T I O N.

	M	W	D	H	'	''
To	1	3	6	19	39	23
Add	3	2	5	11	31	45

	M	W	D	H	'	''
	7	0	1	13	49	21
	5	3	4	11	19	42

	Y	M	W	D	H	'	''
	5	11	3	4	23	52	47
	4	5	2	5	17	47	36
	5	12	1	6	19	36	52
	7	11	2	4	21	46	54

	Y	M	W	D	H	'	''
	3	7	2	5	17	49	47
	7	11	3	6	7	11	11

	5	4	1	4	14	44	57
--	---	---	---	---	----	----	----

	2	10	2	4	13	59	27
--	---	----	---	---	----	----	----

	1	12	3	6	23	59	39
--	---	----	---	---	----	----	----

	3	4	2	5	7	16	19
--	---	---	---	---	---	----	----

S U B T R A C T I O N.

	W	D	H	'	''
From	3	5	7	25	19
Take	2	4	19	11	44

Remains

Proof

	W	D	H	'	''
From	3	4	11	34	37
Take	1	5	14	42	48

Remains

Proof

	Y	M	W	D	H	'	''
From	7	9	1	2	11	27	42
Take	5	11	0	5	20	19	56

Remains

Proof

	Y	M	W	D	H	'	''
From	8	4	0	1	13	42	15
Take	7	8	2	4	13	56	42

Rem.

Proof

(10)

M U L T I P L I C A T I O N . C A S E Ith.

When the Multiplier does not exceed 12.

	W	D	H	'	"		Y	M	W	D	H	'
Mul.	3	5	19	14	24	by 8	Mul.	7	11	3	5	17
					8							11

C A S E IIId.

When the Multiplier is more than 12.

	M	W	D	H	'	"
Multiply	0	3	2	7	34	29
						by 16
						Y M W D H ' "
Product	1	0	1	2	1	11 44

	Y	M	D	H	'	"
Multiply	0	1	1	12	44	3
						by 74
						Y M D H ' "
Product	6	0	1	6	19	42

	M	W	D	H	'	"
Multiply	0	2	2	6	30	45
						by 78
						Y M W D H ' "
Product	3	6	1	2	3	58 30

D I V I S I O N . C A S E Ith.

When the Divisor does not exceed 12.

Y M W D H ' "		Y M D H ' "
D. 3 5 3 6 23 49 57	by 3	D. 7 11 2 4 19 17 29
Q.		Q.
P.		P.

(11)

C A S E IId.

When the Divisor is more than 12.

Y M W D H ' #
Divide 19 7 3 5 20 47 53 by 17

Y M W D H ' #
17)19 7 3 5 20 47 53(1-year

17
2

13
17)33(1 month

17
16

4
17)67(3 weeks

51
16

7
17)117(6 days

102
15

24
17)380(22 hours

34
40

34
6

60

Y M W D H ' #
Facit 1 1 3 6 22 23 59

Continued,

17)407(23'
34

67

51

16

60

17)1013(59"
85

163

153

(10)

Divide

(12)

Divide 75 years of 365 ^{D H M} 5 48 by 59

Quotient 464 ^{D H ' "} 6 57 57 and 57 over

Divide 47 ^{Y M W D H ' "} 7 3 5 23 42 44 by 316

Quotient 1 ^{M W D H ' "} 3 5 20 16 39 and 80 over

To convert TIME into MOTION.

R U L E.

Multiply the degrees, minutes, &c. by 2, and divide the degrees of that product by 30; the Quotient will be hours, and the remainder half, minutes, seconds, &c.—
N. B. In doubling the remainder, the degrees will be minutes, and the minutes seconds, &c.

Convert 2471° 19' into Time.

$$\begin{array}{r} 2 \\ 3 \overline{) 4942} \quad 38 \quad (\\ \underline{16422} \quad 38' \end{array}$$

45' 16" Anf. 164^h 45' 16"

Convert 47 20 30 into Time.

^{H ' "}
Facit 3 9 22

Bring 55° 25' 35" into Time.

^{H ' " "}
Facit 3 41 42 20

To bring TIME into MOTION.

R U L E.

Write down the hours, and half the minutes, seconds, &c. then multiply the hours by 30, taking in the half minutes, to which product affix half the seconds, &c. The half sum thereof will be degrees, minutes, seconds, &c. as required.

Bring	H ' "	into degrees, minutes, &c.
	5 17 43	
	$\frac{1}{2}$ 17 43	
	5 ^h 8' 51" 30 ^{'''}	
	30	
	$\frac{1}{2}$) 158 51 30	
Facit	 79° 25' 45" 	

Convert 21 42 38 into degrees, minutes, &c.

H ' "
0 ' "
Facit 325 39 30

Convert 13 19 18 into degrees, minutes, &c.

H ' "
0 ' "
Facit 199 49 30

O R T H U S:

Put a cypher to the right hand of the hours, and under them set half the sum, under that sum one fourth of the minutes, and under the minutes one fourth of the seconds their sum will be the degrees, minutes, &c. desired.

N. B. In taking the fourth of the minutes, seconds, &c. should there be 1 over set down 15, if two over 30, and if 3 over 45.

C

Bring

Bring ^{H ' "} 7 19 46 into degrees, minutes, &c.
 The hours with a cypher 70
 Half of which is 35
 The fourth of the minutes 4 45
 The fourth of the seconds 11 30
 Facit 109 56 30

Bring ^{H ' "} 5 36 30 into degrees, minutes, &c.
 Facit ^{H ' "} 84 7 30

Bring ^{H ' "} 17 19 20 into degrees, minutes, &c.
 Facit ^{O "} 259 50

REDUCTION OF MOTION.

DEFINITION.

Reduction brings quantities from one denomination to another, still keeping, or retaining the same value

C A S E Ist.
R U L E.

Great names are brought to small by multiplying, small to great by dividing, observing always to multiply, or divide by as many of the less, as make one of the greater; however, it is most usual to multiply, or divide step by step; for, if degrees are to be brought into seconds, bring the degrees first into minutes, and then the minutes into seconds, &c. as example.

In 329 degrees, how many seconds?

$$\begin{array}{r} 60 \\ \hline 19740 \text{ minutes} \\ 60 \end{array}$$

Answer 1184400 seconds

In 1184400 seconds, how many degrees?

$$\begin{array}{r} 6|0) 118440|0 \\ 6|0) 1974|0 \text{ minutes} \end{array}$$

Answer 329 Degrees

In 11 signs, how many seconds?

Answer 1188000 seconds.

In 1188000 seconds, how many signs?

Answer 11 signs.

In 237 degrees, how many minutes and seconds?

Answer 14220 minutes, 853200 seconds.

In 856800 seconds, how many minutes and degrees?

Answer 14280 minutes, 238 degrees.

In 9 signs, how many degrees, minutes, and seconds?

Ans. 270 degrees, 16200 minutes, 972000 seconds.

In 1080000 seconds, how many minutes, degrees and signs?

Answer 18000 minutes, 300 degrees, 10 signs.

C A S E IId.

When a compound number is required to be brought to its lowest denomination

R U L E.

As you multiply, add to it what may be of the next less name; for instance, let it be required to find how many seconds there are in $74^{\circ} 37' 57''$: to perform this, multi-

C 2

ply

ply the degrees by 60, and add to it 37; that will produce the minutes in $74^{\circ} 37'$; then multiply the minutes in $74^{\circ} 37'$, by 60, and add in 57", which will produce the seconds in $74^{\circ} 37' 57''$. Example.

o / "

In $74^{\circ} 37' 57''$ how many seconds?

$$\begin{array}{r}
 \text{60} \\
 \hline
 4477 \text{ minutes in } 74^{\circ} 37' \\
 \text{60} \\
 \hline
 268677 \text{ seconds in } 74^{\circ} 37' 57'' \\
 \hline
 \hline
 \text{o /}
 \end{array}$$

Reduce $59^{\circ} 19'$ to seconds.
Facit 213540 seconds.

s o /

Reduce $3^{\circ} 17' 44''$ to seconds.
Facit 387840 seconds.

s o / "

Reduce $9^{\circ} 19' 42''$ to seconds.
Facit 1040669 seconds.

o / "

Reduce $257^{\circ} 19' 34''$ to seconds.
Facit 926374 seconds.

s o / "

In $11^{\circ} 27' 39'' 57''$ how many seconds?
Answer 1287597 seconds.

The SINGLE RULE of THREE, DIRECT.

D E F I N I T I O N.

This teacheth by three numbers given to find a fourth, which will bear a just proportion to the third, as the second does to the first: also, direct proportion is when
more

more requires more, or less requires less; that is, when the third number is greater than the first, and requires greater than the second; or when the third number is less than the first, and requires less than the second.

To STATE the QUESTION.

R U L E.

Read the question to find what is demanded, make the second number of that name, the first what that commands or is equal in value to it, and the third what governs the demand or answer required.

N. B. The question being stated, bring the first and third numbers into one denomination or name, (when not so) and reduce the second number to the lowest denomination it is given in, then multiply the second and third numbers into each other, and divide that product by the first; the quotient will be the answer to the question in the same denomination as the second number was left in; and should there be a remainder, (to find its value) multiply it into the next inferior denomination to the quotient, and divide that product by the former Divisor.

O F M O T I O N.

If the difference for 1 degree is $19' 49''$, what will be the proportional part for $27' 11''$?

$\begin{array}{r} \text{If } 60 \text{ ————— } \\ \underline{60} \\ 3600 \end{array}$	$\begin{array}{r} 19 \ 49 \text{ ————— } \\ \underline{60} \\ 1189 \end{array}$	$\begin{array}{r} 27 \ 11 \text{ ————— } \\ \underline{60} \\ 1631 \end{array}$
---	---	---

C 3

turn over

Sum continued

$$3600'' \text{ --- } 1189'' \text{ --- } 1631''$$

$$\text{--- } 1631$$

$$\text{--- } 1189$$

$$3567$$

$$7134$$

$$\text{--- } 1189$$

$$36,00) 19392,59 \quad (538'' \div 60$$

$$\text{--- } 180$$

$$8' \quad 58''$$

$$\text{--- } 139$$

$$\text{--- } 108$$

$$312$$

$$\text{--- } 288$$

$$\text{--- } (2459)$$

Ans. $8' 59''$ nearly
the propor. part req.

If the motion of the Moon is $32' 56''$ in one hour, how much does she move in $24' 47''$

Answer $13' 36''$

If the Sun moves $59' 8''$ in one day, how far does he move in 1 month, 2 weeks, 4 days, 15 hours?

Answer $1 \quad 15 \quad 57 \quad 5$

If for 1 degree the difference is $25' 19''$, what will be the proportional part for $49' 29''$?

Answer $20 \quad 53$ nearly

If in one year of 365d. $5^h. 49' 3''$, the Sun moves thro' the Zodiac or 12 signs, what is his motion in one day?

Answer $59' 8''$

When the proportional part for $27' 11''$ is $9' 24''$, what is the difference for 1 degree?

Answer $20' 45''$ nearly REDUC.

REDUCTION OF TIME.

N. B. Reduction, and the Rule of Three of Time, must be performed in the same manner as the rules given in Motion, only observing the different Tables.

C A S E Ist.

Reduce 5 days, to minutes and seconds.

$$\begin{array}{r}
 5 \text{ days} \\
 \underline{24} \\
 120 \text{ hours} \\
 \underline{60} \\
 7200 \text{ minutes.} \\
 \underline{60} \\
 \underline{432000} \text{ seconds.}
 \end{array}$$

Answer 7 200 minutes. 432 000 seconds.

In 432000 seconds, how many days?

$$\begin{array}{r}
 6|0 \) \ 43200|0 \text{ seconds.} \\
 \hline
 6|0 \) \ 720|0 \text{ minutes.} \\
 \hline
 24 \) \ 120 \ (\text{hrs. } 5 \text{ days} \\
 \hline
 120 \ (\text{Answer } 5 \text{ days.}
 \end{array}$$

Reduce 2 months to hours. Answer 1344 hours

In 4838400 seconds, how many months?

Answer 2 months.

In 7 months, how many days, hours, and minutes?

Answer 196 days, 4704 hours, 282240 minutes.

In 241920 minutes, how many hours, days, and weeks?

Answer 4032 hours, 168 days, 24 weeks

In 1 year of 365 days, how many seconds?

Answer 31536000 seconds

In 3369600 seconds, how many minutes hours and days?

Answer 56160 minutes, 936 hours, 39 days

(20)

C A S E IId.

Reduce M W D H into hours
11 3 6 20

4
47 weeks.

7
335 days.

24
1360
670

Answer 8060 hours

Reduce 7 years, of D H ' " to seconds
365 5 49 3
Facit 220898601 seconds.

Reduce M W D H ' to seconds
3 3 5 19 49
Answer 9575340 seconds

From May 12, 7^h. 19' P. M. 1783, unto July 19, 6^h. 24' A. M. 1784, how many minutes?

Answer 624185 minutes.

The RULE of THREE of TIME.

If in one day the difference is 59' 8" what is the difference for 9^h. 27' 49"?

(21)

D	' "	H	' "
1	59 8	9 27 49	
24	60	60	
24 hours	3548	567	
60		60	
1440'		34069	
60		3548	
86 400"		272552	

136276	
170345	
102207	
864 1208768 12)	1399" ÷ 60
864	23' 19"
3447	
2592	
8556	
7776	
7808	
7776	
(3212)	

Answer 23' 19".

If in 6 hours the Sun moves 14' 47", in what time does he move 15 9°?

M	W	D	H	'	"
Answer	1	1	4	13	43 5

If the Moon in 1 day moves 13° 10' 35", in what time will she make a revolution?

D	H	'	"
Answer	27	7	43 6

If the motion for 3h is 1° 42' 29", in what time is it 57' 47"?

H	'	"
Answer	1	41 29

If

If on the 21st, of March at noon, the Sun and Moon are in the first point of Aries, at what time will the Sun and Moon be next in conjunction, the Sun moving in one day $59' 8''$, and the Moon $13^{\circ} 10' 35''$

D H ' "

Answer 29 12 43 45 nearly

If the Sun in three days moves $2^{\circ} 57' 25''$, in what time does he make a revolution?

D H ' "

Answer 365 5 48 20

To work proportions by the proportional Logarithms from table XV. Requisite tables.

C A S E Ist.

When the terms do not exceed three hours, or three degrees.

R U L E.

Find the pro. log. of the first term, in degrees, minutes, and seconds, or hours, minutes, and seconds, and take its arith. com. in like manner as in common log. observing to take the index from 9; to which add the pro. log. of the second and third terms, rejecting 10 in the index, and you will have the pro. log. of the fourth term required.

E X A M P L E S.

If the difference for 1° is $25' 19''$, what will be the difference for $49' 29''$?

O ' "

As	1	0	0	pro. log. co. ar.	9 5229
	..	25	19	pro. log.	8510
	::	49	29	pro. log.	5608
	..	20	53	pro. log.	9356

If the motion in 1 hour is $37' 24''$, what is the motion in $17' 19''$

Answer 10' 48"

CASE

C A S E II d.

When the terms exceeds three hours, or three degrees.

R U L E.

Enter the table for the hours and minutes, under the title of minutes and seconds; do the same with the degrees and minutes, and work exactly as in case 1st,

E X A M P L E.

If 24 hours give 1 degree, what will 5 hours 20 minutes give?

H '
 For 24 seek 24 pro. log. co. ar. 9 1249

10° 4771

5^h. 20' 5' 20" 1 5283

13' 20" 1 1303

Answer 13' 20'

If the Moon in 24 hours moves 14° 36', what is her motion in 7^h. 10'?

0 /

Answer 4 22

If the Moon moves 5° 12' in 8^h. 15', how long will he be in moving 13° 16'

H /

Answer 21 3

PRAC.

CASE

PRACTICAL GEOMETRY.

DEFINITIONS and PRINCIPLES.

1. Geometry is a science which treats of the descriptions, properties, and relations of magnitudes in general or of such things where length, or length and breadth, or length breadth and thickness are considered.

2. A point is that which is without parts or dimensions and is only an assignable place in a plane, denoted by a point as at A,

3. A line has length without breadth. It is called a right line when it is the shortest distance between two points as A B.

Or a curved line when it is not the shortest distance, as C D.

N. B. A line is bounded by parts or points, and usually denoted by letters, (*viz.*) one at each end, A B. C D.

4. A superficies or surface, is a magnitude with length and breadth, and is bounded by lines, as Q.

5. A solid hath length breadth and thickness, its boundaries are superficies, as S.

N. B. Magnitudes are but of three kinds, (*viz.*) lines, superficies, and solids.



7. Parallel

Y.

descrip
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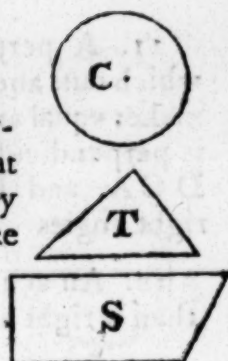
end,

O



Paralle

6. A plane, or plane figure, is a superficies which lies evenly, or perfectly flat between its limits, and may be bounded by one curved line, but not with less than three or more right lines, as C. T. S.

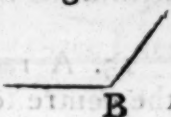


7. Parallel lines do not incline one to another, but stay in the same plane, equally distant from a ——— b each other in all their parts; therefore, A ——— B if infinitely extended can never meet, as A B, a b.

8. A plane angle is the aperture or inclination of two lines in the same plane, meeting in a point, as A.



9. A right lined angle is formed by two right lines, the point where the lines meet is called the angular point, as B. The lines which form the angle are called legs, as A B, C B. A ——— B



N. B. An angle is usually marked with three letters, and that at the angular point is always to be read the middle letter, as A B C. or C B A. each of which denotes the angle B:

10. The measure of a right lined angle is an arc, as A B. contained between the legs C A. C B. including the angle, the angular point C. being the centre of the arc.

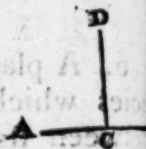


N. B. An angle is said to be greater or less by the length of the arc, and not by the legs.

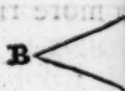
D

11 A

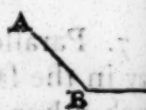
11. A perpendicular is that right line which cuts another at right angles, or which makes equal angles on both sides: thus DC is perpendicular to AB . when the angles DCA . and DCB . are equal, or are two right angles



12. An acute angle, is that which is less than a right angle, as ABC .

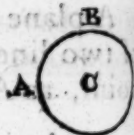


13. An obtuse angle, is that which is greater or more than a right angle, as ABC .



N. B. Acute and obtuse angles, are called oblique angles

14 A circle is a plane figure; bounded by an uniform curve-line, called the circumference, as ABC . which is every where equally distant from one point, as C within the figure, called its Centre.



15. A radius is a right line, drawn from the centre to the circumference, as RA .



N. B. All the radii of the same circle are equal.

16 The circumference of every circle, is supposed to be divided into 360 equal parts, called degrees; each degree into 60 equal parts, called minutes; and each minute into 60 equal parts, called seconds, &c.

N. B. An arc is any part of the circumference, as AB .



17. A chord is a right line, joining the ends of an arc, as A. B. and is said to subtend that arc: it divides the circle into two parts, called segments.



18. A diameter, is a chord passing thro' the centre, as A. B. and divides the circle into two equal parts, called semi-circles; each being equal to 180 degrees.



19. A quadrant is half a semi circle, and is made by the radius standing perpendicular upon the diameter on the centre, as D D. and is equal to 90 degrees.



20. A sector is a figure included between two radii of a circle, and that arc of its circumference where they touch, as A C B.



21. A triangle is a plane figure, bounded by three lines.

22. An equilateral triangle is that whose sides or fides are all equal, as E.



23. An Isosceles triangle is that which has two equal sides, as I.



24. A scalenum triangle, is that which hath all its sides unequal, as S.

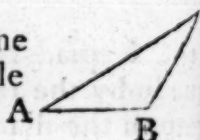


25. A right angled triangle, is that which has one right angle, as A.



N. B. All triangles that have not a right angle, are generally called oblique. — Again, the longest side of a right angled triangle, is called the hypotenuse, and the other side legs.

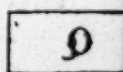
26. An obtuse angled triangle, hath one obtuse angle, as the angle B, in the triangle A B C.



27. An acute angled triangle, has all its angles acute, as the triangle A.



28. A quadrangle is a plane figure, bounded by four right lines, as Q.

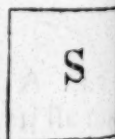


N. B. A quadrangle is usually expressed by letters at the opposite angles, and all quadrangles that have opposite sides parallel and equal, are commonly called parallelograms.

29. The diagonal of a quadrangle, is a line drawn from one angle to its opposite angle, as D.



30. A square is a parallelogram of four equal sides, standing at right angles, as S.



PROB

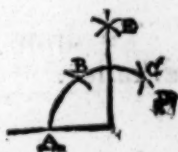
PROBLEMS OF PRACTICAL GEOMETRY.

P R O B L E M I.

From a given point on a given right line, to erect a perpendicular on any part thereof, at the end or otherwise, without altering the Compasses

CONSTRUCTION.

With any convenient distance in the Compasses describe an arc A D, and make the given point the centre; with one foot in A. describe the arc B. and from B describe the arc C, then from B, and C. strike equal arcs to cut at E, which intersection will make the perpendicular from the given point.



P R O B L E M II.

From a given point without, to let fall a perpendicular on a given right line, or be the point on a given right line without altering the Compasses.

CONSTRUCTION.

With one foot on the given point describe an arc A B, to cut the given line (when the point is without) then from A and B. strike equal arcs at C. which intersection will give the perpendicular from the given point; but if the given point be on the given right line, proceed downwards, as Problem 1st, directs.



D 3

PROB.

P R O B L E M III.

To bise^t, or divide a given right line, into two equal parts.

C O N S T R U C T I O N .

With any distance greater than half the given line, at the extremes thereof, describe the arcs A B. and C D. through their intersections draw a line E F. which line will divide the given line into two equal parts.



P R O B L E M IV.

To draw a line parallel to a given right line, at any distance.

C O N S T R U C T I O N .

Let the given line be A B. and distance C D. with the length of C D. any where with one foot of the Compasses on the given line A B. strike the arcs E and F. then draw a line to touch the two arcs, and it will be parallel to the given right line A B.

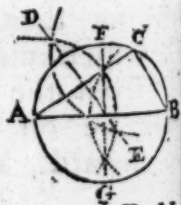


P R O B L E M V.

To describe a circle about any given triangle.

C O N S T R U C T I O N .

At pleasure draw the triangle A B C. and bise^t, or divide A B and A C. into two equal parts; in performing of which, where the lines D E. and F G. intersect each other, gives the centre of the circle round the triangle.



B. N.

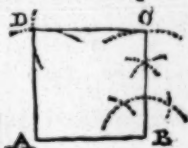
N. B. By the like operation may a circle be drawn, whose circumference shall pass through three given points, provided they do not lie in one right line: — Also, the segment of a circle being given, the whole circle may be described.

P R O B L E M VI.

Upon a given right line to describe a square.

C O N S T R U C T I O N .

Let A B. be the given right line, from B. raise a perpendicular, then with the length of A B. strike the arc C. and from C and A. strike equal arcs to cut each other at D. draw the lines A D. and D C. which will form the square.

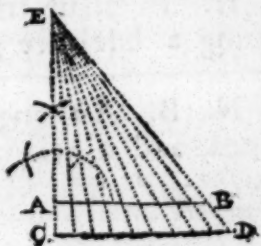


P R O B L E M VII.

To divide a given right line into any proposed number of equal parts.

C O N S T R U C T I O N .

Let A B. be the given right line, on which from A. draw a perpendicular thro' E and C. and parallel to A B. draw C D. at pleasure, on which set off the number of equal parts the right line is to be divided into, (suppose 9) begin at C. towards D. observing the sum of the number of equal parts must be longer than the given right line; from each of these parts draw lines thro' A B. beginning at D B. to cut the perpendicular line as at E. to which place all the lines must be drawn, and where they cut the right line A B. will divide it into the number of equal parts proposed:

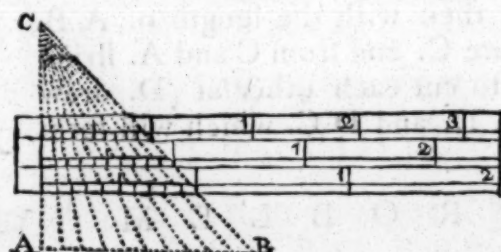


P R O B L E M VIII.

To make scales of equal parts.

C O N S T R U C T I O N .

Divide any right line into 10 equal parts, as A B. at either end thereof, as at A. erect a perpendicular, and from each of these parts draw lines to cut the perpendicular, at any one fixt place, suppose at C. then draw parallel lines to A B. which lines will form scales of equal parts, as per figure.



P L A N E O R L I N E A L T R I G O N O M E T R Y .

D E F I N I T I O N S a n d P R I N C I P L E S .

I. Plane Trigonometry is a science which teaches us to compute the length of the sides, and quantity of the angles, of plane triangles.

II. In plane triangles if three things (one of which being a side) are given, the rest may be found.

N. B. An angle is the intersection of two right lines, and a triangle three.

P R O B .

P R O B L E M I.

On a given right line A B. to make a right angle.

C O N S T R U C T I O N .

On one of the extreme points at B. with 60 degrees off the line of chords radius, describe an arc, upon which lay off 90 degrees of the same line of chords, from C to D. draw the line B D. thro' D. then is the angle B. a right angle.



P R O B L E M II.

On a given right line to make an acute angle.

C O N S T R U C T I O N .

Proceed with the arc as with the right angle, setting off the given number of degrees on the arc, instead of 90 degrees.



Make an acute angle equal to 36 degrees.

P R O B L E M III.

On a given right line to make an obtuse angle.

C O N S T R U C T I O N .

Proceed as before with the sweep, on which lay off from C to Y. half the degrees, and from Y to D. the same.



Make an obtuse angle equal to 130 degrees.

P R O B .

P R O B L E M IV.

To make a right angled triangle, having the hypotenuse and one $\angle$ given.

C O N S T R U C T I O N .

Draw a line at pleasure on one extreme point, as at A. make the given acute angle, on the line that forms the angle, lay off the hypotenuse, on the extreme point of the hypotenuse make an angle equal to the complement of the given angle, cutting the first line drawn.

N. B. The complement of any given angle is found by subtracting it from 90 degrees, and the supplement from 180 degrees.

Make a right angled triangle. Hypotenuse equal to 80 miles, and the angle A. equal to $22^{\circ} 30'$

$$\begin{array}{r} \text{Angle A } 22^{\circ} 30' \\ \hline \angle C \quad 67^{\circ} 30' \\ \hline \end{array}$$



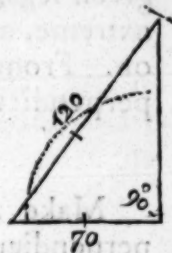
P R O B L E M V.

To make a right angled triangle, having the hypotenuse and one leg given.

C O N .

CONSTRUCTION.

Draw a right line equal to the given leg, on one extreme make a right angle at length, on the other extreme with the hypotenuse radius, describe an arc cutting the perpendicular, which extreme and intersection join with a right line



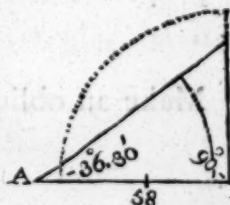
Make a right angled triangle. Hypotenuse equal to 120' base equal to 70'

PROBLEM VI.

To make a right angled triangle, having one leg and an angle given.

CONSTRUCTION.

Draw a right line equal to the given leg, on one extreme make a right angle at length, from the other extreme draw a right line making an angle equal to the given one, and cut that right line which formed the right angle.



Make a right angled triangle. Base 58 miles, and angle A. equal to $36^{\circ} 30'$

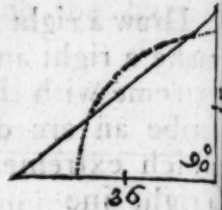
PROBLEM VII.

To make a right angled triangle, having the legs given.

CON.

CONSTRUCTION.

Draw a right line equal to one of the given legs, erect a perpendicular on one extreme, and lay off the other leg thereon. From the extremes of the base and perpendicular draw the hypotenuse.



Make a right angled triangle. Base equal to 36' perpendicular equal to 28'

P R O B L E M VIII.

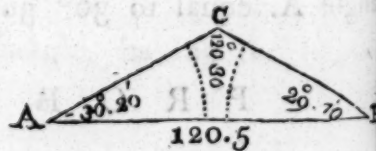
To make an oblique angled triangle, the angles and one side given.

CONSTRUCTION.

Draw a right line equal to the given side, on the extremes draw right lines, making angles equal to those proposed, cutting each other.

Make an oblique angled triangle. $\begin{cases} \text{Angle A} = 30^{\circ}.20' \\ \text{Angle C} = 120.30 \\ \text{Side A B. } 120'.5 \end{cases}$

Angle A	30 ^o .20'
Angle C	120.30
	150.50
	180
Angle B	29 .10



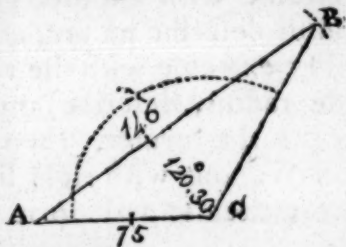
PRO

P R O B L E M IX.

To make an oblique angled triangle, having two sides and one opposite angle given.

C O N S T R U C T I O N.

Draw a right line equal to one of the given legs, on one extreme make an angle equal to the given one, drawing the line at length that forms the angle, make the side opposite the given angle radius, and on the other extreme describe an arc to cut the line that formed the angle, then from that extreme thro' the intersection draw a right line, which will form the triangle.



Make an oblique angled plane triangle. $\left\{ \begin{array}{l} AC \ 75 \\ AB \ 146 \end{array} \right\}$

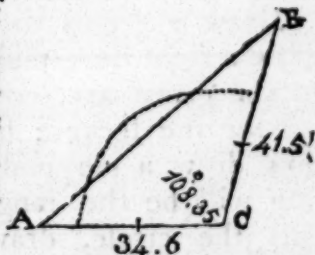
Angle C $120^{\circ}.30'$

P R O B L E M X.

To form an oblique angled plane triangle, having two sides and the included angle given.

C O N S T R U C T I O N.

Draw a right line equal to one of the given sides, on which make an angle equal to the given included angle, then draw another right line equal to the other given side, and join the extreme of each line and the triangle will be formed.



Make an oblique angled plane triangle. $\left\{ \begin{array}{l} AC \ 34'.6 \\ BC \ 41'.5 \end{array} \right\}$

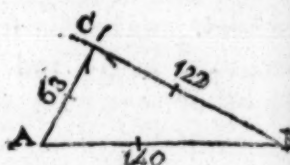
Angle C $108^{\circ}.35'$

P R O B L E M XI.

To make an oblique angled plane triangle, having the sides given.

C O N S T R U C T I O N .

Draw a line equal to one of the given legs, on one extreme with another given side radius describe an arc, and on the other extreme with the remaining side radius, describe another arc to cut the former, then join the interfections with right lines, and the extremes will form the triangle.



Make an oblique angled plane triangle. $\left\{ \begin{array}{l} A B \quad 140' \\ A C \quad 63 \\ B C \quad 122 \end{array} \right\}$

P R O B L E M XII.

To draw the sine, tangent and secant, of any arc of a circle.

C O N S T R U C T I O N .

Draw a radius to the given circle, from the centre draw a right line, making an angle with the radius equal to the given arc, continued at length without the circle for the secant; from the other extreme of the radius draw a perpendicular cutting the secant, which line will be the tangent. Again, where the secant cuts the circle, draw a parallel line to the tangent till it meets the radius, which line will be a sine.

N.B.

N. B. A fine is a right line drawn from the radius to the periphery, or is half the chord of twice the arc. — A tangent is a right line which touches the edge of the periphery and terminates the secant. — A secant is a right line drawn from the centre thro' the periphery, by which the tangent is terminated.

Draw the fine, tangent, and secant, of an arc of 60 degrees:



The CONSTRUCTION of the PLANE SCALE.

R U L E S.

1. With any radius describe a circle A B E D. draw the diameter A B. and perpendicular thereto from C the centre draw E D. continued thro' E to S parallel to which draw B T.

2. Divide the quadrants A E. and B E. into 9 equal parts, and from these parts in the quadrant B E. draw right lines parallel to C E. 'till they cut the diameter A B. then is C B. a line of fines, and B C. a line of semi-fines.

3. From C. the centre, thro' the several divisions in the quadrant B E. draw right lines 'till they cut the line B T. which line will then become a line of tangents, and from A, to the several divisions on the quadrant B E. cut C E. and it will be a line of semi-tangents.

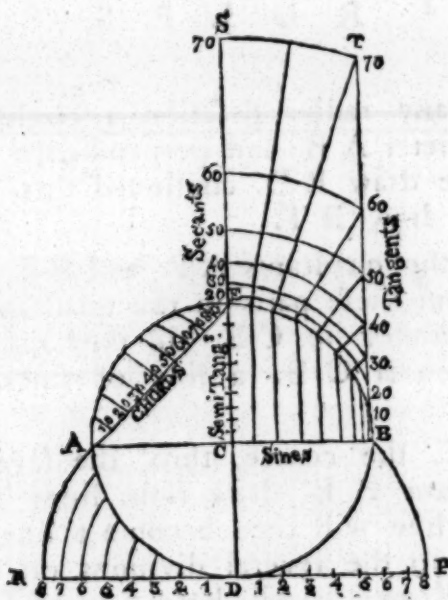
N. B. E 2 3. From

4. Set one foot of the compasses in C. and extend the other to the several divisions 10, 20, 30, &c. on the tangent line B T. from which draw arcs to cut the line E S. and it will be then a line of secants.

5. Having already divided the quadrant A E into 9 equal parts, draw the line A E. set one foot of the Compasses in A. and from these parts strike arcs to cut A E. then will A E be a line of chords.

6. Divide the quadrant D A. into 8 equal parts from which parts, with one foot of the Compasses in D. sweep arcs to cut R D. and it will be a line of rhumbs, each division equal to $11^{\circ} 15'$ upon the line of chords.

7. From D. sweep B P. and make D P. a scale of equal parts.



OF LOGARITHMS.

1. LOGARITHMS are a series of numbers so contrived, that by them the work of multiplication may be performed by addition, and that of division by subtraction: again, if you divide the logarithm of any number by 2, the quotient will be the logarithm of the square root of that number, and if divided by 3, the quotient will be the logarithm of the cube root.

2. In logarithms the figure or figures to the left hand of the decimal part is called index, and the figures to the right hand logarithms.

3. The index of any number under 10 is a cypher, between 10 and 100 is 1, between 100 and 1000 is 2, &c. and is called affirmative.

4. The index of any tenth part of an unit is $\overline{1}$, of any hundredth part $\overline{2}$, of any thousandth part $\overline{3}$, &c. and is called negative.

For Example thus.

Whole numbers. Index logarithms.

$$4358 = 0.63929$$

$$43.58 = 1.63929$$

$$435.8 = 2.63929$$

$$4358. = 3.63929$$

$$.4358 = \overline{1}.63929$$

$$.04358 = \overline{2}.63929$$

$$.004358 = \overline{3}.63929$$

To

To resolve Problems in Plane Trigonometry.

DEFINITIONS and PRINCIPLES.

1. IN a right angled triangle if two things, besides the right angle, (one thereof being a side) are given, a third may be found.

2. In oblique angled triangles, three things and one of them a side must be given to find a fourth.

3. In right angled triangles make one side radius, and the others will be either a sine, tangent or secant.

4. When the hypotenuse is radius, each side is the sine of its opposite angle, as per figure 1st.



5. When the base is radius the hypotenuse is secant, and the perpendicular tangent of the included angle between the base and hypotenuse, (as per figure 2d.)



6. When the perpendicular is radius, the hypotenuse is secant, and the base tangent of the included angle, between the perpendicular and hypotenuse, (as per fig. 3d.)



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degrees
to one
in the i

7th.
a dash ;

The

The following Rules and Observations I beg most strongly to recommend to every learner, to be well acquainted with them all before they proceed to resolve any of the Problems; and also the preceding three figures of sines, tangents, and secants.

GENERAL RULES and OBSERVATIONS.

1st. To find a side, begin with an angle or radius, and to find an angle, begin with a side.

2d. After making any side radius say, as the name of the given side (worked from) is to its length, so is the name of the side required to its length, and the contrary.

3. When a angle or arc is greater than 90 degrees; the sine tangent or secant of its supplement must be used, the complement of any arc or angle, is found by subtracting it from 90, and the supplement from 180 degrees.

4th. In a plane triangle among the things given in order to find the rest, one of them must be a side.

5th. In every triangle three things must be given to find the rest; and they are either. *First*, Two sides and an angle opposite to one of them. *Second*, Two angles and a side opposite to one of them. *Third*, Two sides and the included angle. *Fourth*, Their three sides.

6th. Radius is the sine of 90 degrees, a chord of 60 degrees, and the tangent of 45 degrees; they are all equal to one another. The tabular radius is expressed by 10 in the index with cyphers.

7th. Sides or angles which are given, are marked with a dash; but when required, with a cypher,

8th. Every

8th. Every circle or circumference is equal to 360-degrees, and every semicircle to 180 degrees.

9th. The sum of the angles of every triangle, is equal to 180 degrees; and if two angles in a triangle are given, the third is found by adding the two given angles together, and subtracting their sum from 180 degrees.

10th. A right angle is equal to 90 degrees, an obtuse angle is greater, and an acute angle is less; consequently every obtuse angle is greater, and every acute angle is less than a right angle.

11th. In a triangle, if one angle is acute and another 90 degrees, the acute angle given subtracted from 90 degrees leaves the other acute angle; for in every right angled triangle, the sum of the two acute angles are equal to the right angle equal to 90-degrees.

N. B. I. shall give no directions for projecting the figures through rectangled and oblique trigonometry, by reason I am certain the directions already given in plane trigonometry are sufficient. And I have also given such examples in rectangled trigonometry under six different problems, as to make it impossible for any question to be given but what must fall under one or the other of the above problems, throughout all its variations; a thing not common to be met with, although of the utmost consequence to every one studying the doctrine of rectangled trigonometry.

OF WORKING

PROPORTIONS BY LOGARITHMS,

WHEN the proportion is direct, take the arithmetical complement of the first term, the logarithm of the second term, and the logarithm of the third term, and add them together, abating 10 in the index, their sum will be the logarithm of the fourth term or answer sought.

N. B. If radius is the first term, the index and logarithm are cyphers; but when radius is the second or third term, the index is 10, and the logarithm is cyphers; and again, when the index of the first term is 10, in taking the arithmetical complement the index must be 1, (that is 1 bad or negative.) Now to find the arithmetical complement, begin at the index, and write what each figure wants of 9, except the last, which take from 10. — To check or examine the complement arithmetical of any logarithmetical sine, tangent, &c. when the sine is taken out look at the co. secant, and when the tangent is taken out look at the co. tangent and the contrary.

Another Method to Work Proportions by Logarithms, when Direct.

ADD the logarithms of the second and third terms together, from that sum subtract the logarithm of the first term, the remainder is the logarithm of the fourth term sought. But I make choice of the former method.

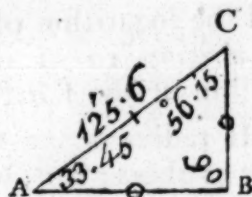
N. B. When an angle or arc is greater than 90 degrees, the sine tangent or secant of its supplement must be used, the complement of an arc or angle is found by subtracting it from 90 degrees, and the supplement from 180 degrees:

P R O B L E M Ith.

The angles and hypotenuse given; the base and perpendicular required?

In the right $\triangle ABC$ $\left\{ \begin{array}{l} \angle A \ 33^{\circ} .45' \\ AC \ 125 . 6 \end{array} \right\}$ given $\left\{ \begin{array}{l} AB \\ \text{and} \\ CB \end{array} \right\}$ req.

$$\begin{array}{r} \angle A \quad 90^{\circ}.00' \\ \quad 33 .45 \\ \hline \angle C \ 56 .15 \\ \hline \end{array}$$



Making AC rad. to find AB. Making AC rad. to find CB.

As radius $= 90^{\circ} = 0.00000$ As radius $= 90^{\circ} = 0.00000$

$\therefore AC = 125.6' = 2.09899$ $\therefore AC = 125.6' = 2.09899$

$\therefore S\angle C = 56.15 = 9.91985$ $\therefore S\angle A = 33.45 = 9.74474$

$\therefore AB = 104.4 = 2.01884$ $\therefore CB = 69.78 = 1.84378$

Making AB rad. to find AB. Making AB rad. to find CB.

As sec. $\angle A \ 33^{\circ} .45' = 1.91985$ As sec. $\angle A \ 33^{\circ} .45' = 1.91985$

$\therefore AC = 125.6 = 2.09899$ $\therefore AC = 125.6 = 2.09899$

$\therefore \text{Rad.} = 90. = 10.$ $\therefore \text{Tang.} \angle A \ 33.45 = 9.82488$

$\therefore AB = 104.4 = 2.01884$ $\therefore CB = 69.78 = 1.84378$

Making CB rad. to find AB. Making CB rad. to find CB.

As sec. $\angle C \ 56^{\circ} .15' = 1.74474$ As sec. $\angle C \ 56^{\circ} .15' = 1.74474$

$\therefore AC = 125.6 = 2.09899$ $\therefore AC = 125.6 = 2.09899$

$\therefore \text{Tan.} \angle C \ 56.15 = 10.47511$ $\therefore \text{Rad.} = 90. = 10.$

$\therefore AB = 104.4 = 2.01884$ $\therefore CB = 69.78 = 1.84378$

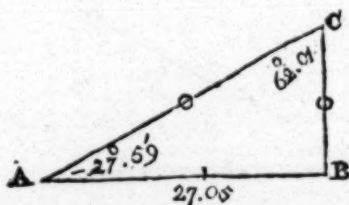
P R O B

P R O B L E M IIId.

The angles and base given ; the perpendicular and hypo-
thenuse required ?

the right $\triangle ABC$ $\left\{ \begin{array}{l} \angle C 62^{\circ}.01' \\ AB 27'.05 \end{array} \right\}$ given $\left\{ \begin{array}{l} CB \\ \text{and} \\ AC \end{array} \right\}$ req.

$$\begin{array}{r} 90^{\circ}.00' \\ \angle C \ 62 \ 01 \\ \hline \angle A \ 27 \ 59 \end{array}$$



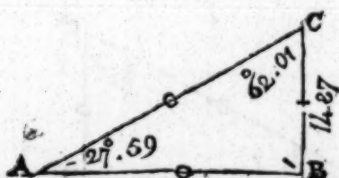
Making AC rad. to find AC.	Making AC rad. to find CB.
As $S\angle C =$	As $S\angle C =$
AB =	.. AB =
Rad. =	$S\angle A =$
AC = $30'.63$	.. CB = $14'.37$
Making AB rad. to find AC.	Making AB rad. to find CB.
As Rad. =	As Rad. =
AB =	.. AB =
Sec. $\angle A =$	.. $T\angle A =$
AC = $30'.63$	.. CB = $14'.37$
Making CB rad. to find AC.	Making CB rad. to find CB.
$T\angle C =$	As $T\angle C =$
AB =	.. AB =
Sec. $\angle C =$	.. Rad. =
AC = $30'.63$	.. CB = $14'.37$

P R O B.

P R O B L E M III.

The perpendicular and angles given; the base and hypotenuse required?

In the right $\triangle ABC$ $\left\{ \begin{array}{l} BC = 14'.87 \\ \angle A = 27^\circ.59' \end{array} \right\}$ given $\left\{ \begin{array}{l} AB \\ AC \end{array} \right\}$ req.



$$\begin{array}{r} 90^\circ.00' \\ \angle A \quad 27.59 \\ \hline \angle C \quad 62.01 \\ \hline \end{array}$$

Making AC rad. to find AC. Making AC rad. to find AB

$$\begin{array}{l} \text{As } S\angle A = \\ \therefore CB = \\ \therefore \text{Rad.} = \\ \therefore AC = 30'.63 \end{array}$$

$$\begin{array}{l} \text{As } S\angle A = \\ \therefore CB = \\ \therefore S\angle C = \\ \therefore AB = 27'.05 \end{array}$$

Making AB rad. to find AC. Making AB rad. to find AB

$$\begin{array}{l} \text{As } T\angle A = \\ \therefore CB = \\ \therefore \text{Sec}\angle A = \\ \therefore AC = 30'.63 \end{array}$$

$$\begin{array}{l} \text{As } T\angle A = \\ \therefore CB = \\ \therefore \text{Rad.} = \\ \therefore AB = 27'.05 \end{array}$$

Making CB rad. to find AC. Making CB rad. to find AB

$$\begin{array}{l} \text{As Rad.} = \\ \therefore CB = \\ \therefore \text{Sec}\angle C = \\ \therefore AC = 30'.63 \end{array}$$

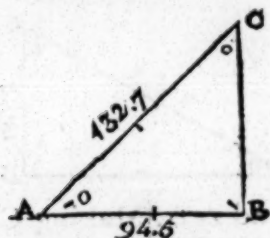
$$\begin{array}{l} \text{As Rad.} = \\ \therefore CB = \\ \therefore T\angle C = \\ \therefore AB = 27'.05 \end{array}$$

P R O B

P R O B L E M IVth.

hypo The base and hypotenuse given; the angles and perpendicular required?

req. In the right $\triangle ABC$ $\left\{ \begin{array}{l} AB=94'.5 \\ AC=132.7 \end{array} \right\}$ giv. $\left\{ \begin{array}{l} \angle A \angle C \\ \text{and} \\ CB \end{array} \right\}$ req.



Making AC rad. to find $\angle C$. Making AB rad. to find $\angle A$.

As AC =
.. Rad. =
: AB =
.. $S\angle C = 45^{\circ}.24'$

As AB =
.. Rad. =
: AC =
.. $\text{Sec. } \angle A = 44.36$

Working from AC.

Making AC rad. to find BC.
As Rad. =
.. AC =
: $S\angle A$ =
.. CB = $93'.18$

Working from AB.

Making AC rad. to find CB.
As $S\angle C$ =
.. AB =
: $S\angle A$ =
.. CB = $93'.18$

Making AB rad. to find CB.
As $\text{Sec. } \angle A$ =
.. AC =
: $T\angle A$ =
.. CB = $93'.18$

Making AB rad. to find CB.
As Rad. =
.. AB =
: $T\angle A$ =
.. CB = $93'.18$

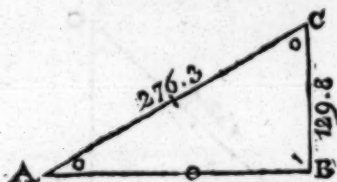
Making CB rad. to find CB.
As $\text{Sec. } \angle C$ =
.. AC =
: Rad. =
.. CB = $93'.18$

Making CB rad. to find CB.
As $T\angle C$ =
.. AB =
: Rad. =
.. CB = $93'.18$

P R O B L E M Vth,

The hypotenuse and perpendicular given; the angle
and base required?

In the right $\triangle ABC$ $\left\{ \begin{array}{l} AC=276.3 \\ CB=129.8 \end{array} \right\}$ given $\left\{ \begin{array}{l} \angle A \\ \angle C \\ AB \end{array} \right\}$ req.



Making AC rad. to find $\angle A$.

As AC =

.. Rad. =

$\therefore CB =$

.. $S\angle A = 28^{\circ}.01'$

Making CB rad. to find $\angle C$.

As CB =

.. Rad. =

$\therefore AC =$

.. $Sec.\angle C = 61^{\circ}.59'$

Working from AC.

Making AC rad. to find AB.

As Rad. =

.. AC =

$\therefore S\angle C =$

.. AB = $243'.9$

Working from CB.

Making AC rad. to find AB.

As $S\angle A =$

.. CB =

$\therefore S\angle C =$

.. AB = $243'.9$

Making AB rad. to find AB.

As $Sec.\angle A =$

.. AC =

$\therefore Rad. =$

.. AB = $243'.9$

Making AB rad. to find AB.

As $T\angle A =$

.. CB =

$\therefore Rad. =$

.. AB = $243'.9$

Making CB rad. to find AB.

As $Sec.\angle C =$

.. AC =

$\therefore T\angle C =$

.. AB = $243'.9$

Making CB rad. to find AB.

As Rad. =

.. CB =

$\therefore T\angle C =$

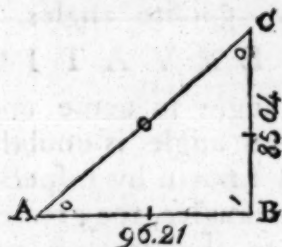
.. AB = $243'.9$

PROB.

P R O B L E M VIth.

The base and perpendicular given; the hypotenuse and angles required?

In the right $\triangle ABC$ $\left\{ \begin{array}{l} AB=96'.21 \\ CB=85'.04 \end{array} \right\}$ giv $\left\{ \begin{array}{l} \angle A \angle C \\ \& AC \end{array} \right\}$ req.



Making AB rad. to find $\angle A$. Making CB rad. to find $\angle C$.

As AB =

As CB =

.. Rad. =

.. Rad. =

.. CB =

.. AB =

.. $T\angle A = 48'.28$

.. $T\angle C = 48'.32$

Working from AB.

Making AC rad. to find AC.

Working from CB.

As $S\angle C =$

Making AC rad. to find AC.

As $S\angle A =$

.. AB =

.. CB =

.. Rad. =

.. Rad. =

.. AC = $128'.4$

.. AC = $128'.4$

Making AB rad. to find AC.

Making AB rad. to find AC.

As Rad. =

As $T\angle A =$

.. AB =

.. CB =

.. Sec. $\angle A =$

.. Sec. $\angle A =$

.. AC = $128'.4$

.. AC = $128'.4$

Making CB rad. to find AC.

Making CB rad. to find AC.

As $T\angle C =$

As Rad. =

.. AB =

.. CB =

.. Sec. $\angle C =$

.. Sec. $\angle C =$

.. AC = $128'.4$

.. AC = $128'.4$

O B.

OBLIQUE TRIGONOMETRY

C A S E Ist.

R U L E.

In all plane triangles, the sides are in just proportion to the sines of their opposite angles, and vice versa.

O B S E R V A T I O N S.

1st. If a given angle is acute and opposite a lesser given side, a required angle is doubtful whether acute or obtuse, but is easily known by inspecting the triangle.

2^d. In all plane triangles, the greatest angles are known by being opposite to the greatest or longest sides, and vice versa.

3^d. If the given angle is obtuse, the req. angles are acute.

4th. If the proportion produces an acute angle when it should be obtuse, its supplement is the required angle.

P R O B L E M I.

Two sides and an opposite angle given; the other angles required?

In the oblique $\triangle ABC$ $\left\{ \begin{array}{l} AB \ 112 \ .5 \\ BC \ 79 \ .02 \\ \angle C \ 42 \ .27 \end{array} \right\}$ giv. $\left\{ \begin{array}{l} \angle A \\ \& \\ \angle B \end{array} \right\}$ req.

$$\text{As } AB =$$

$$\therefore \sin C =$$

$$\therefore BC =$$

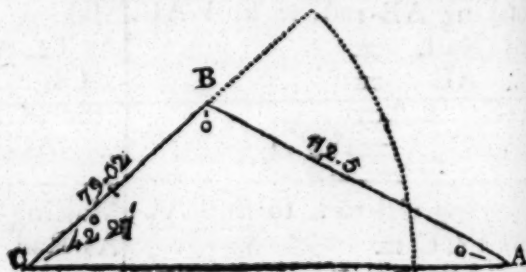
$$\therefore \sin A = 28^{\circ}.18$$

$$\angle C = 42' .27$$

$$70 \ .45$$

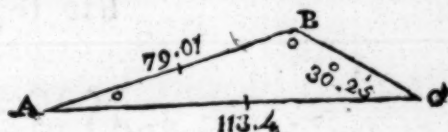
$$180 \ .00$$

$$\angle B = 109 \ .15$$



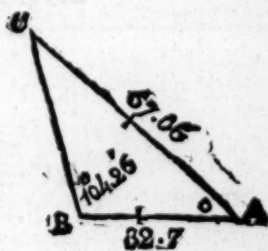
In

In the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AC = 113'.4 \\ AB = 79.01 \\ \angle C = 30^\circ.25' \end{array} \right\}$ giv. $\left\{ \begin{array}{l} \angle A \\ \& \\ \angle B \end{array} \right\}$ req.



$$\begin{aligned} \text{As } AB &= \\ \therefore S\angle C &= \\ \therefore AC &= \\ \therefore S\angle B &= 46.36 \\ &\quad 180.00 \\ \hline \angle B &= 133.24 \\ \angle C &= 30.25 \\ \hline &\quad 163.49 \\ &\quad 180.00 \\ \hline \angle A &= 16.11 \end{aligned}$$

In the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AC = 57.06 \\ AB = 32.7 \\ \angle B = 104^\circ.26' \end{array} \right\}$ giv. $\left\{ \begin{array}{l} \angle A \\ \& \\ \angle C \end{array} \right\}$ req.



$$\begin{aligned} \text{As } AC &= \\ \therefore S\angle B &= \\ \therefore AB &= \\ \therefore S\angle C &= 33^\circ.42' \\ \angle B &= 104.26 \\ \hline &\quad 138.08 \\ &\quad 180.00 \\ \hline \angle A &= 41.52 \end{aligned}$$

F 3

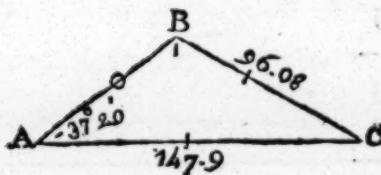
P R O B.

(54)

P R O B L E M · II d.

Two sides and an opposite angle given ; the other
side required ?

In the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AC = 147.9 \\ BC = 96.08 \\ \angle A = 37^{\circ}.20' \end{array} \right\}$ given $\{ AB \}$ req.



$$\begin{array}{l} \text{As } BC = \\ \therefore S\angle A = \\ \therefore AC = \\ \therefore S\angle B = 69^{\circ} \\ \quad \quad 180 \end{array}$$

$$\begin{array}{l} \text{As } S\angle A = \\ \therefore CB = \\ \therefore S\angle C = \\ \therefore AB = 83'.17 \end{array}$$

$$\begin{array}{l} \angle B = 111 \\ \angle A = 37.20 \end{array}$$

$$\begin{array}{r} 148.20 \\ 180.00 \end{array}$$

$$\angle C = 31.40$$

P R O B

(55)

P R O B L E M III.

Two angles and one side given; the other two sides required ?

In the obl. $\triangle ABC$ $\left\{ \begin{array}{l} \angle A 116^{\circ}.30' \\ \angle B 35.20 \\ AB 120.9 \end{array} \right\}$ given $\left\{ \begin{array}{l} AC \\ BC \end{array} \right\}$ req.



$$\begin{array}{l} \angle A = 116^{\circ}.30' \\ \angle B = 35.20 \end{array}$$

$$\begin{array}{r} 151.50 \\ 180.00 \\ \hline \end{array}$$

$$\angle C = 28.10$$

$$\begin{array}{l} \text{As } S\angle C = \\ \therefore AB = \\ \therefore S\angle B = \\ \therefore AC = 148.1 \end{array}$$

$$\begin{array}{l} \text{As } S\angle C = \\ \therefore AB = \\ \therefore S\angle A = \\ \therefore CB = 229.2 \end{array}$$

CASE

C A S E II.

R U L E.

As the sum of two given sides is to their difference, is the tangent of half the sum of the opposite angles to the tangent of half their difference; the half difference added to the half sum gives the greater angle, but subtracted leaves the lesser,

P R O B L E M II.

Two sides and their included angle given; the other two angles required?

In the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AB = 76'.02 \\ AC = 54. \\ \angle A = 63^\circ.26' \end{array} \right\}$ $\left\{ \begin{array}{l} \angle C \\ \& \\ \angle B \end{array} \right\}$ req.

$$\begin{array}{r} 180^\circ.00' \\ \angle A = 63.26 \\ \hline \end{array}$$

$$\begin{array}{r} AB = 76'.02 \\ AC = 54. \\ \hline \end{array}$$

$$\frac{1}{2} 116.34 = \text{Sum of } \angle B \& \angle C$$

$$130.02 = \text{S. of sides}$$

$$58.17 = \text{Half sum.}$$

$$22.02 = \text{Difference}$$

$$\text{As } AB + AC =$$

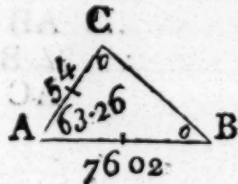
$$\therefore AB - AC =$$

$$\therefore T \frac{1}{2} \text{ sum op. } \angle s = 58.17$$

$$\therefore T \frac{1}{2} \text{ their diff.} = 15.19$$

$$\angle C = 73.36$$

$$\angle B = 42.58$$



P R O

P R O B L E M III.

Two sides and their contained angle given; the other angles and the side required?

R U L E.

Proceed as before, and find the other two angles; then find the side by problem 1st.

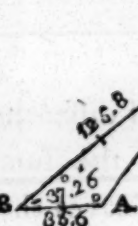
the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AB = 35'.6 \\ BC = 125.8 \\ \angle B = 37^{\circ}.26 \end{array} \right\}$ giv. $\left\{ \begin{array}{l} \angle A \\ \angle C \\ AC \end{array} \right\}$ req.

$\left\{ \begin{array}{l} C \\ B \end{array} \right\}$ req.

$$\begin{array}{r} C = 125.8 \\ A = 35.6 \\ \hline \end{array}$$

$$161.4 \text{ Sum.}$$

$$90.2 \text{ Diff.}$$



$$180^{\circ}.00$$

$$37.26 = \angle B$$

$$\frac{1}{2}) 142.34 \text{ sum of } \angle s$$

$$71.17 = \frac{1}{2} S. \text{ op. } \angle s$$

of side

difference

$$BC + BA =$$

$$BC - BA =$$

$$T. \frac{1}{2} \text{ sum op. } \angle s = 71.17$$

$$T. \frac{1}{2} \text{ their diff.} = 58.46$$

$$\angle A = 130.03$$

$$\angle C = 12.31$$

$$\text{As } S \angle C =$$

$$\therefore AB =$$

$$\therefore S \angle B =$$

$$\therefore AC = 99.85 =$$

$\triangle B$

CASE

PRO

C A S E III.

R U L E.

In all plane triangles, as the base is to the sum of the other two sides, so is their difference, to the difference of the segments of the base made by a perpendicular let fall from its opposite angle when it falls within the triangle or added to the alternate base when it falls without

In the first case, the half difference added to the half base, gives the greater segment, but subtracted leaves the lesser.

In the second case, the half difference of the segments added to the half base, gives the sum of the base and external base, but subtracted leaves the external base.

N. B. Having found the two segments made by letting fall the perpendicular, proceed to find the angles by rectangled trigonometry, having the hypotenuse and base given.

P R O

P R O B L E M I A.

When the perpendicular falls within the triangle, the three sides given; the angles required?

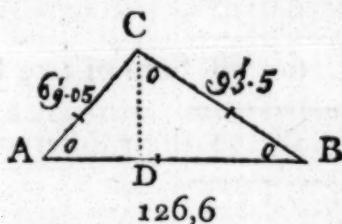
the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AB=126.6 \\ AC=69.05 \\ BC=93.5 \end{array} \right\}$ giv. $\left\{ \begin{array}{l} \angle A \\ \angle C \\ \angle B \end{array} \right\}$ requir.

$$AC=69.05$$

$$CB=93.5$$

$$\text{Sum}=162.55$$

$$\text{Diff.}=24.45$$



$$AB =$$

$$\frac{1}{2})31'.39$$

$$BC+AC=$$

$$BC-AC=$$

$$BD-DA=31'.39$$

$$15.69=\text{half the diff. of seg.}$$

$$63.3=\text{half the base.}$$

$$78.99=DB \text{ the greater seg.}$$

$$47.61=DA \text{ the lesser seg.}$$

$$\text{As } AD =$$

$$\therefore \text{Rad.} =$$

$$\therefore AC =$$

$$\therefore \text{Sec.} \angle A = 46^{\circ}.25 =$$

$$\text{As } DB =$$

$$\therefore \text{Rad.} =$$

$$\therefore BC =$$

$$\therefore \text{Sec.} \angle B = 32.21$$

$$\angle A = 46.25$$

$$78.46$$

$$180.00$$

$$\angle C = 101.14$$

PROB.

P R O B L E M II.

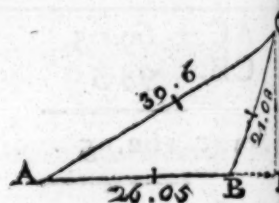
When the perpendicular falls without the triangle.

In the obl. $\triangle ABC$ $\left\{ \begin{array}{l} AB=26.05 \\ AC=39.6 \\ BC=21.08 \end{array} \right\}$ $\text{giv. } \left\{ \begin{array}{l} \angle A \\ \angle B \\ \angle C \end{array} \right\}$ requir.

$$\begin{array}{l} AC=39.6 \\ BC=21.08 \end{array}$$

$$60.68 \text{ Sum of two sides}$$

$$18.52 \text{ their difference}$$



$$2) 26.05$$

$$13.025 = \text{half base}$$

$$21.57 = \text{half of } AC$$

$$34.595 = AE$$

$$26.050 = AB$$

$$8.545 = BE$$

$$21.57 = \text{half diff. of seg.}$$

$$\text{As } AB =$$

$$\therefore AC + BC =$$

$$\therefore AC - BC =$$

$$\therefore AE + BE = 43'.14$$

$$\text{As } AE =$$

$$\therefore \text{Rad.} =$$

$$\therefore AC =$$

$$\therefore \text{Sec } \angle A = 29^\circ.08'$$

$$\text{As } BC =$$

$$\therefore S \angle A =$$

$$\therefore AB =$$

$$\therefore S \angle C = 36^\circ.57'$$

$$\angle A = 29.08$$

$$66.05$$

$$180.00$$

$$113.55 = \angle$$

N.

gle.
requir
N.B. Case 3d, may be solved by the following Rule, (z.) as the longest side is to the sum of the other two sides, so is the difference of the two shortest sides to the difference of the segments made by a perpendicular let from the angle opposite the longer side; the half difference of the segments added to half the longest side is the greater segment, and subtracted leaves the less. Or thus. Add the three sides together and take of their sum, from the half sum subtract each side, and take the arith. comp. of the half sum. The arith. comp. of the remainder opposite the angle required, and the logs of the other two remainders, add these four logs together, the half sum thereof gives the co-tangent of the required angle.

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ALTIMETRY AND LONGIMETRY.

DEFINITIONS and PRINCIPLES.

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55=L

N.

1st. BY altimetry and longimetry, or heights and distances, is meant the interval between two known points in space.

2d. When the given points are in one plane, a line drawn from one to the other is called a distance, whether the plane be horizontal or inclined.

G

3d. When

3d. When the plane is vertical or perpendicular, it is then called a height or altitude.

4th. Again, when one point is in a given plane and another out of it, if above, a perpendicular let from it on the plane is called its altitude, but if below a perpendicular, therefrom to the point is called a depression.

5th. The common instrument used in altimetry, &c. is the circle or part thereof divided into degrees, fixed with sights, &c. proper for measuring or taking of angles, which by one general name may be called an angular instrument, tho' in practice it has several, as the theodolite, protractor, plane table, mariner's compass, &c.

6th. To this must be added the length of an accessible line, such as a foot, yard, pole, chain, &c.

C A S E I I.

To find the height of objects being at sea, or on Terra Firma, when the object is perpendicular to the surface, and the distance to it can be measured.

R U L E.

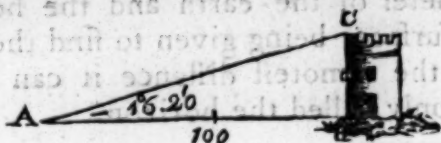
At any convenient known distance from the object find the angle the top of it makes; then by rectangled trigonometry (having the angles and base given) find the perpendicular, and its done.

E X A M P L E.

At sea I found the altitude of a castle (after allowing for the height of my eye above the surface) to make an

angle

angle of $16^{\circ}.20'$ when the distance from it was 100 fathoms, required the castle's true height?



Answer. The castle's height 29.3 fathoms.

C A S E II.

When the object is not perpendicular, such as hills, mountains, rocks, &c.

R U L E.

At any convenient distance find the angle the top of it makes, then go farther off, or nearer to it in a direct line, of which line be careful to have its true length) and find the angle the top then makes, which angles at both stations being carefully taken, the perpendicular height is found by trigonometry.

E X A M P L E.

Being at sea, I observed the top of a mountain to make an angle of $7^{\circ}.30'$ after sailing four miles in a direct line towards the mountain. I then observed it to make an angle of $13^{\circ}.20'$. Required the perpendicular height.



Ans. The height is 1043 fathoms.

C A S E III.

The diameter of the earth and the height of an eye above the surface, being given to find the distance from the eye to the remotest distance it can see of the surface, commonly called the horizon.

R U L E.

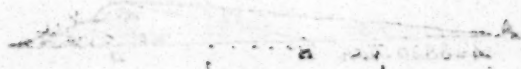
To the earth's diameter, which is according to Sir *Isaac Newton's* measure 41,798,117 feet, add the height of the eye above the surface, then multiply it by the eye's height above the surface, and take the square root of that product, and it will be the true distance required.

E X A M P L E.

Being at sea in fine weather, I went to the top-gallant mast head, which was 150 feet above the surface; how far was the remotest distance of the surface I could see?

S O L U T I O N.

Being at sea in fine weather, I went to the top-gallant mast head, which was 150 feet above the surface; how far was the remotest distance of the surface I could see?



Feet

And the height of the eye above the surface is 150 feet.

C A S E

(65)

Feet.

41798117 the earth's diameter.

150

41798267

150

2089913350

41798267

5280 = 1 mile

)6269740050(79181.00.0 (14.996

49

528

149)1369

1341

2638

2112

1581) 2874(

1581

5261

4752

15828)129300(

126624

5090

4752

158361) 267650

158361

3380

3168

109.289

212

Answer. 14.996 miles:

G 3

C A S E

C A S E IVth.

The diameter of the earth and the height of an eye above the surface being given, and also the height of some distant object lying in the same direct right line with the eye, to find the distance between the eye and the object.

R U L E.

Proceed as in case 3d, to find the remotest distance you can see of the surface, and do the same with the object's height; then add the two distances together, and it will give the true distance from the eye to the object.

E X A M P L E.

Sailing towards the land, I ordered a man to the fore-top-gallant-mast-head to look out, when his eye was 123 feet above the surface, and he saw the top of a castle whose height from the surface was known to be 300 feet. I demand how far we were at that time from the castle?

Ans. 34,897 miles.

C A S E Vth.

To ascertain the distance of places by seeing a flash from a piece of ordinance, or otherwise, and some time after hearing the report or sound made by the explosion.

R U L E.

As a second of time is to 1142 feet, so is the number of seconds between seeing the flash and hearing the report or sound, to the true distance.

E X

E X A M P L E.

At sea I saw a flash from a ship in distress, and 50 seconds afterwards I heard the report. At what distance was the ship that fired ?

	Feet.	Yds.	
As 1" —————	1142 —————		50"
	50		
	—————		
	5280) 57100 (10 miles.		
	5280		
	—————		
	4300		
		1760 = 1 mile	
		3	
		—————	
		5280 feet in a	
		mile.	

Anf. 10 miles, 4300 feet.

I observed a flash of lightning, and 25 seconds after I heard the thunder roar. At what distance was the cloud from me ?

Anf. 5 miles, 2150 feet.

O N C H R O N O L O G Y.

D E F I N I T I O N S and P R I N C I P L E S.

1. Chronology is the art of measuring time.
2. By it we have rules to find the golden number, epact, moon's age, time of high water, &c.

P R O B L E M I A.

To find biffextile or leap year.

D E.

DEFINITION.

It is so called from its leaping one day more that year, than in a common year. The common year has only 365 days, whereas the leap year has 366 days; then February has 29 days, but in common years only 28.

R U L E.

Divide the year of our Lord by 4, if nothing remains it is leap year; but if 1, 2, or 3, remains, it is so many years after leap year.

What is the year 1786, a common or a leap year?

$$\begin{array}{r} 4 \overline{)1786} \\ \underline{446} \\ 2 \end{array}$$

Ans. A common year, and the 2d, after leap year.

What was the year 1776, a common or a leap year?

Ans. It was a leap year.

What will be the year 1799, a common or a leap year?

Ans. It will be a common year, and the third after leap year.

P R O B L E M Hd.

To find the year of the cycle, commonly called the prime, or golden number.

D E F

D E F I N I T I O N.

This cycle of the moon's revolution of 19 years containing all the variations of the days on which the new and full moons happen, after which they fall on the same days they did 19 years ago, or before. But when a common 100th year falls in the cycle, the new and full moons (according to the new stile) will fall a day later than otherwise.

R U L E.

Add one to the year of our Lord, divide that sum by 19, the remainder is the golden number ; but if nothing remains, that year is the 19th of the cycle, or the golden number is 19.

What is the golden number for the year 1786 ?

$$1786$$

$$1$$

$$19 \overline{) 1787 (94}$$

$$171$$

$$77$$

$$76$$

Ans. 1 the golden number.

What was the golden number for the year 1776 ?

Ans. 10.

What will be the golden number for the year 1799 ?

Ans. 14 the golden number.

P R O B.

((970))

PROBILHEIM IIIA.

To find the epact 'till the year 1800.

DEFINITION.

The epact of the year is the moon's age at its commencement, that is, the time between the last new moon and the first minute of the first day of January. Or the moon's age on the 31st of December, is the epact for the following year. Consequently the epact can never exceed 29, and it advances 11 every year.

RULE.

Subtract one from the prime or golden number. Multiply the remainder by 11. Divide that product (if it exceeds 30) by 30. The remainder is the epact.

What was the epact for the year 1786?

$$\begin{array}{r} 1786 \\ 1 \\ \hline 19)1787(94 \\ 171 \\ \hline 77 \\ 76 \\ \hline 1 \end{array}$$

1 The golden number.

Ans. 0 the epact.

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What was the epact for the year 1776?

Ans. 9 the epact.

What will be the epact for the year 1799?

Ans. 23 the epact.

P R O B L E M IVth.

To find the age of the moon.

D E F I N I T I O N.

The age of the moon is the number of days that have elapsed since the last change, which age can never exceed 30 days.

R U L E.

To the epact add the number and day of the month, their sum if under 30, is the moon's age, if above 30, divide by 30, the remainder is her age. The moon's age taken from 30 leaves the day of the next change, and 15 added to, or taken from the day of the change, the day of the full moon.

N. B. When the solar and lunar years begin together, the moon's age on the first of each month, or the month-epacts are called the numbers of the month, which are follows:

I N

((72))

IN COMMON YEARS.

Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0	2	1	2	3	4	5	6	8	8	10	10

IN LEAP YEARS.

Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0	2	2	3	4	5	6	7	9	9	11	11

To calculate the Numbers of the Month.

R U L E.

Add the number of days from the first of January, to the first of the month you want to know the number for, (both days inclusive) and divide that sum by 29.53; the nearest whole number to the remainder is the number required,

E X A M P L E.

Let it be required to find the number of the month for July, 1786; it being a common year.

Days

- 31 January
- 28 February
- 31 March
- 30 April
- 31 May
- 30 June
- 1 July

$$\begin{array}{r} 29.53 \overline{) 182.00} \quad (6 \\ \underline{177.18} \end{array}$$

$$\begin{array}{r} 24 \text{ 1} \\ \underline{4.82} \end{array}$$

Ans. 5, it being nearest.

What

What age was the moon the 26th, of April, 1786 ?

o The Epact found by Problem 3d.

2 Number of the month.

26 Day of the month.

Ans. 28 moon's age.

Of what age was the moon the 17th, of Sept. 1776 ?

Ans. 5 days.

What will be the moon's age the 19th, of Jan. 1799 ?

Ans. 12 days the moon's age.

P R O B L E M V.

To find the moon's culminating, southing, or being on the meridian.

D E F I N I T I O N.

The moon's culminating, or southing, is the time she comes on the meridian of any place; and it is every day later by 48 minutes; found by the hours in one day being divided by 30, as every moon from new to new, passes the meridian 30 times, therefore, 24 hours divided by 30, gives 48 minutes.

R U L E.

Multiply her age by 8, and cut off one figure to the right hand; the left hand figure or figures will be hours, and the right hand figure so many six minutes.

H

N, B. Should

N. B. Should this be less than 12 hours, it is the time of her southing after mid-day; but if greater, then 12 hours taken from it, leaves the southing after midnight, that is, on the following morning.

At what time was the moon on the meridian the 26th, of April, 1786?

Her age 28 days, found by prob. 4.

$$\begin{array}{r}
 8 \\
 \hline
 22 \overline{) 4} = 22^{\text{h.}} \quad 24' \\
 \quad \quad \quad 12 \quad \quad 0 \\
 \hline
 \quad \quad \quad 10 \quad 24
 \end{array}$$

Anf. at 24' past 10, A. M.

That is on the morning of the 27th,

At what time was the moon on the meridian the 17th, of Sept. 1776?

Anf. at 4 o'Clock P. M.

At what time will the moon be on the meridian the 19th, of Jan. 1799?

Anf. at 36' past 9 o'Clock, P. M.

P R O B L E M VI.

To find the time of full sea or high water, at any proposed place whatever.

RULES

R U L E S.

1st. To the southing of the moon add the flowings of the place, that is, the point of the compass making full sea, (which is the moon's bearings at the time of high water on the full, and change days for the place proposed) their sum is the time of high water.

2d. The point of the compass making full Sea on the full and change days, may be found in tide tables for that purpose; and if any place flows on full and change as under-mentioned, you add the hours and minutes, as against it to the moon's southing, and it gives the time of high water.

3d. Should this sum not exceed a tide, which is 12hrs. 24' it is the time of high water after mid-day; but if greater than 12hrs. 24' take 12hrs. 24' from it, and it gives the time of high water after mid day; again, when greater than two tides, that is, 24hrs. 48' subtract 24hrs. 48' from it, and it leaves the time of high water after mid-day; lastly, 24 minutes subtracted from the time thus found, leaves the time of high water on the morning of the same day; for 24 minutes nearly is the difference of each tide, and on every day there are two tides.

	hrs. m.		hrs. m.
North and South =	12 0	East and West =	6 0
N by E = S by W =	0 45	E by S = W by N =	6 45
N.NE = S.SW =	1 30	E.SE = W.NW =	7 30
NE by N, SW by S =	2 15	SE by E = NW by W =	8 15
NE = SW =	3 0	SE = NW =	9
NE by E = SW by W =	3 45	SE by S = NW by N =	9 45
E.NE = W.SW =	4 30	S.SE = N.NW =	10 30
E by N = W by S =	5 15	S by E = N by W =	11 15
		South = North =	12
	H 2		At

At what time was it high water at London-bridge,
the 26th, of April, 1786?

22h. 24' The moon's southing by prob. 5.
2 37 At London-bridge it flows NE by N $\frac{1}{2}$ E.

25 01

24 48

0 13

Anf. high water 13' past noon,

At what time was it high water at London-bridge,
the 17th, of Sept. 1776?

Anf. at 6h.37' P. M.

At what time will it be high water at Plymouth,
the 19th, of Jan. 1799?

Anf. at 3h. 12' P. M.

P R O B L E M VIIth.

To find the golden number, epact, moon's age,
moon's southing, and the time of high water, at any
place and time whatever, all under one.

R U L E S.

1st. Add 1 to the year of our Lord, divide that
sum by 19, the remainder is the golden number.

N. B. If nothing remains that year is the 19th, of
the cycle.

2d. Subtrac

2d. Subtract one from the prime or golden number, multiply the remainder by 11, divide that product by 30, the remainder will be the epact.

3d. To the epact add the number of the month and day of the month together, which gives the moon's age.

4th, The moon's age multiplied by 4 and divided by 5, gives the moon's southing in hours, and the remainder so many 12 minutes.

5th, To the moon's southing add the flowings of the place, and it will be the time of high water at that place; observing 3d. rule, prob. 6th.

N. B. This operation must be performed for the same year for which the golden number and epact were found.

What is the golden number and epact for the year 1786; and what age is the moon, and when high water at London-bridge, on the 26th, of April, that year.

$$\begin{array}{r}
 1786 \\
 \underline{1} \\
 19) 1787 \text{ (94} \\
 \underline{171}
 \end{array}$$

$$\begin{array}{r}
 77 \\
 \underline{76}
 \end{array}$$

1 The golden number,

1

0 The epact.

2 Number of the month.

26 Day of the month.

28 Moon's age.

4

$$\begin{array}{r}
 5) 112 \text{ (}
 \end{array}$$

22 : 24' The moon's southing.

2 : 37 London-bridge's flowing.

25 : 04'

24 : 48

13' High water P. M.

Anf. The golden number is 1, the epact 0, the moon's age 28 days, her southing 22^{hrs.} 24' and it was high water 13' past noon.

INSTRUC.

I N S T R U C T I O N S

T O M A K E

L O G L I N E S.

THE log is a flat piece of wood in shape of a sector, and on its circular side there is a sufficient quantity of lead to make it swim upright in the water, and to it is fastened a line of 50 or 60 fathoms, called the log line, which is divided into equal parts, called knots; each of which bears a like proportion to a nautical mile, as half minute does to an hour. Now to make a log line to a half minute glass, the space from knot to knot is 50 feet, tho' a just proportion is 51 feet; but as it is found by experience that 51 feet would be too much, it being much safer to have a ship's reckoning before than after her, therefore 50 feet is allowed the proper length of each knot to an half minute glass, the knots being to be counted at 10, 12 or 14 fathoms from the log, as it may be clear of the ship, her wake, &c. Before they begin to count the log line) from whence they begin to reckon, there is a piece of red rag, from which place is reeved between the strands of the log line pieces of twine with knots on from 1 to 5, 6, or 7, &c. to shew the ship's rate of sailing; but should the ship sail so fast as to run the log line off the reel before the half minute glass is out, in that case they generally make use of a quarter minute glass, and so double every knot.

N. B. Be sure great care is taken to measure the log line very often, for fear it should have stretched and so deceive you in the true distance sailed.

I N S T R U C -

INSTRUCTIONS to correct Distances given by the
LOG LINE and HALF MINUTE GLASS.

C A S E Ist.

When the glass is faulty.

R U L E.

As the seconds run by the glass is to 30 seconds, so is
the distance run by the log, to the true distance.

E X A M P L E S.

Suppose a ship sails at the rate of $5\frac{1}{2}$ knots per log
but measuring the glass it is found to run 35 seconds
what was the true distance sailed?

As $35'' \dots 30'' :: 5' \cdot 5'' \dots 4' \cdot 7''$ miles, the true distance sailed

$$\begin{array}{r} 35)165.0(4.7 \\ \underline{140} \\ 250 \\ \underline{245} \\ 5 \end{array}$$

Again, a ship sails per log $7\frac{1}{2}$ knots per hour, but
finds the glass to run only 25 seconds, what was the
true rate of the ship's sailing.

As $25'' \dots 30'' :: 7' \cdot 5'' \dots 9'$ miles, the true distance sailed.

$$\begin{array}{r} 25)225.0(9 \\ \underline{225} \\ \dots \end{array}$$

C A S

C A S E IId.

When the log line is faulty.

R U L E.

As 50 feet is to the distance measured between knot and knot, so is the distance run per log, to the true distance.

E X A M P L E.

Suppose a ship sailing at the rate of 6 miles per hour by the half minute glass, but measuring the log line finds from knot to knot 55 feet. Required the true rate of her sailing.

feet feet
As 50 .. 55 :: 6' .. 6'.6 miles, the true distance sailed.

$$\begin{array}{r} 5,0 \overline{) 33.0} \\ \underline{6,6} \end{array}$$

Again, a ship sails per log $4\frac{1}{2}$ knots per hour, by a half minute glass, but finding the log line to measure from knot to knot only 45 feet, what was the true rate of her sailing?

feet feet
As 50 .. 45 :: 4'.5 .. 4'.05 miles, the true distance sailed.

$$\begin{array}{r} 4.5 \\ \underline{225} \\ 180 \\ \underline{50 \overline{) 202.5}} \\ 4.05 \end{array}$$

C A S E

C A S E IIIId.

When both the log line and glass are faulty.

R U L E.

Multiply 3 times the measured length of a knot by the distance run per log, that product divided by 5 times the seconds that the glass runs, will give the true distance.

E X A M P L E.

Suppose a ship sails 6 knots per log line of 45 feet a knot, while a glass is but 25 seconds running out. What is the ship's true rate of sailing?

$$\begin{array}{r} 25'' \\ 5 \\ \hline 125 \\ \hline \end{array}$$

$$\begin{array}{r} 45 \text{ feet} \\ 3 \\ \hline 135 \\ 6 \\ \hline \end{array}$$

$$125 \overline{) 810.00} (6.48 \text{ miles.}$$

$$\begin{array}{r} 750 \\ \hline 600 \\ 500 \\ \hline 1000 \\ 1000 \\ \hline \end{array}$$

Ans. 6.48 miles, her true distance sailed per hour which is nearly $6\frac{1}{2}$ miles.

A T A B L

TABLE, shewing how to make LOG LINES in a
just PROPORTION to different GLASSES, from 22
seconds to 38 seconds.

TO MAKE THE TABLE.

R U L E.

Multiply the seconds in the glass by 5, and divide
that product by 3, which gives the length of the log
in feet to one knot.

T A B L E.

Glasses.	Length of Log Line to 1 knot.	
Seconds.	Feet.	Inches.
22	36	8
23	38	4
24	40	0
25	41	8
26	43	4
27	45	0
28	46	8
29	48	4
30	50	0
31	51	8
32	53	4
33	55	0
34	56	8
35	58	4
36	60	0
37	61	8
38	63	4

O N N A V I G A T I O N

DEFINITIONS and PRINCIPLES.

1st. Navigation is the art of piloting a ship thro' the ocean, discovering the latitude, longitude, course, distance, &c. or how to pilot a vessel to any known port.

2d. Poles are two points on the earth's surface diametrically opposite each other, one the North pole the other the South pole; at these poles is the greatest latitude, that is, they are 90 degrees distant from the equator.

3d. The equator is a great circle on the earth's surface equally distant from each pole, from whence latitude is reckoned.

4th. Meridians are imaginary circles on the earth's surface, passing thro' both poles at right angles to the equator.

5th. Latitude is the nearest distance of any place from the equator. It begins at the equator and ends at the poles; the greatest latitude is 90 degrees,

6th. Parallels of latitude are circles parallel to the equator.

7th. Difference of latitude is an intercepted arc of a meridian, between two parallels of latitude, which can never exceed 180 degrees; or it is the nearest distance between two parallels of latitude.

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East, the
d. Draw
course
Westerly.

8th. Longitude on the earth is an arc of the equator, shewing the East and West distance of a place from some fixed meridian where longitude is reckoned to begin; it never can exceed 180 degrees, and when it is to the Eastward of the meridian, from whence you begin to reckon longitude, it is East longitude, and if to the Westward West longitude; and if a ship sails towards the East or West untill she passes the opposite meridian, or 180 degrees, she then changes her longitude, or comes into a longitude of a contrary name.

9th. Difference of longitude, meridian distance or departure, is an intercepted arc of the equator between the meridians of two places, and it never can exceed 180 degrees.

10th. The horizon is that apparent circle which limits the spectators view on the sea, whose eye is always supposed to be in the centre of the horizon.

11th. When a ship sails upon the equator both poles appear in the horizon.

12th. When a ship sails towards the equator she is said to depress the pole, and from the equator to rise to the pole.

GENERAL RULES.

1st. In all proportions of navigation make the upper part of your slate or book North, then the right side East, the left West, and the lower end South.

2d. Draw the departure towards the right hand when the course is Easterly, and to the left hand when it is Westerly.

I

3d. Plane

3d. Plane and middle latitude failings are used near the line, but Mercator's every where else.

N. B. I shall give directions to project the first figure throughout all the different failings, as also work the whole of plane sailing by inspection, as well as mathematically, which I think will be sufficient for any learner to know the use of the difference of latitude and departure Table.

NAUTICAL OBSERVATIONS

C A S E Ist.

The latitude of two places given, the difference of latitude required?

R U L E.

If the latitudes are of the same name their difference is the difference of latitude required, but if the latitudes are of different names, their sum gives the difference of latitude required.

What is the difference of latitude between London in latitude $51^{\circ}.31'N.$ and Gibraltar $36^{\circ}.06'N.$

London's latitude $51^{\circ}.31' N.$

Gibraltar's lat. $36^{\circ}.06' N.$

Difference of lat. 15.25
 60

An^r , 925 miles.

What

What is the difference of latitude between London and the river Plata; the latitude of London being $51^{\circ}.31' \text{ N.}$ and the river Plata $36^{\circ}.00' \text{ S.}$

Ans. 3251 miles.

C A S E IId.

The latitude of one place, and the difference of latitude given; the latitude of the other required?

R U L E.

If the given latitude, and difference of latitude are of the same name, their sum is the latitude of the same name; but if the given latitude and difference of latitude have contrary names, their difference is the latitude required, of the same name with the greater.

E X A M P L E S.

A ship from latitude $46^{\circ}.30' \text{ N.}$ sails Northward untill her difference of latitude be 164 miles. What latitude is the ship in?

Latitude sailed from $46^{\circ}.30' \text{ N.}$

Diff. of lat. $164 \div 60 = 2 \quad 44 \text{ N.}$

Ans. latitude in $49^{\circ}.14' \text{ N.}$

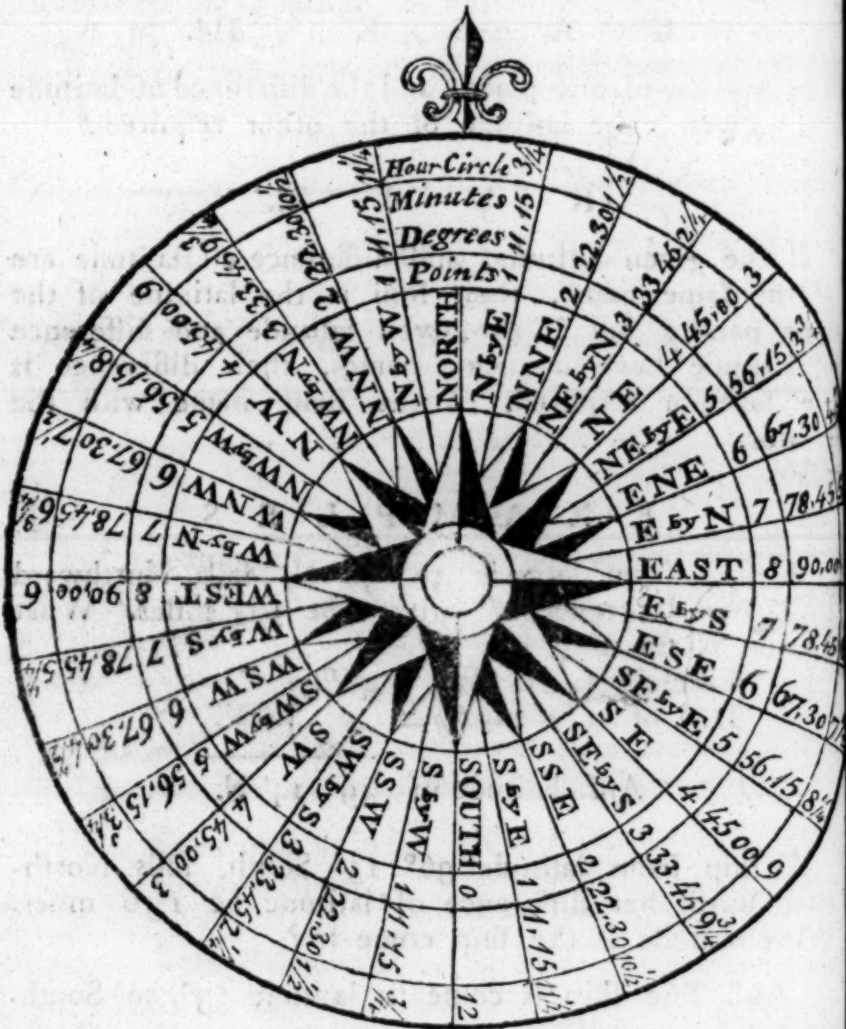
A ship from latitude $36^{\circ}.15' \text{ South,}$ sails Northward untill her difference of latitude be 136 miles. What latitude is the ship come to?

Ans. The ship is come to latitude $33^{\circ}.59' \text{ South.}$

A COMPLEAT COMPASS.

Repeat the compass as per figure.

N.B. Read N. for north, E. for east, S. for south, and W. for west.



A TABLE of the ANGLES which every Quarter of a Point makes with the Meridian.

North.	South.	Points.	Deg.	Min.	North.	South.
		$\frac{1}{4}$	2	" 49		
		$\frac{1}{2}$	5	" 37		
		$\frac{3}{4}$	8	" 26		
N by E	S by E	1	11	" 15	N by W	S by W
		$1\frac{1}{4}$	14	" 4		
		$1\frac{1}{2}$	16	" 52		
		$1\frac{3}{4}$	19	" 41		
NNE	SSE	2	22	" 30	NNW	SSW
		$2\frac{1}{4}$	25	" 19		
		$2\frac{1}{2}$	28	" 7		
		$2\frac{3}{4}$	30	" 56		
NE by N	SE by S	3	33	" 45	NW by N	SW by S
		$3\frac{1}{4}$	36	" 34		
		$3\frac{1}{2}$	39	" 22		
		$3\frac{3}{4}$	42	" 11		
NE	SE	4	45	" 00	NW	SW
		$4\frac{1}{4}$	47	" 49		
		$4\frac{1}{2}$	50	" 37		
		$4\frac{3}{4}$	53	" 26		
NE by E	SE by E	5	56	" 15	NW by W	SW by W
		$5\frac{1}{4}$	59	" 4		
		$5\frac{1}{2}$	61	" 52		
		$5\frac{3}{4}$	64	" 41		
ENE	ESE	6	67	" 30	WNW	WSW
		$6\frac{1}{4}$	70	" 19		
		$6\frac{1}{2}$	73	" 7		
		$6\frac{3}{4}$	75	" 56		
E by N	E by S	7	78	" 45	W by N	W by S
		$7\frac{1}{4}$	81	" 34		
		$7\frac{1}{2}$	84	" 22		
		$7\frac{3}{4}$	87	" 11		
Eaft.		8	90	" 00	Weft.	

PLANE SAILING. DEFINITION.

It is the application of rectangled trigonometry.

N. B. In solving plane sailing questions you will call the hypotenuse the distance run, the perpendicular the difference of latitude, which is always North or South, and the base the departure, and that is always East or West; the angle opposite the departure or base represents the course, and that opposite the difference of latitude or perpendicular, the complement of the course.

C A S E Ist.

The course and distance run given.

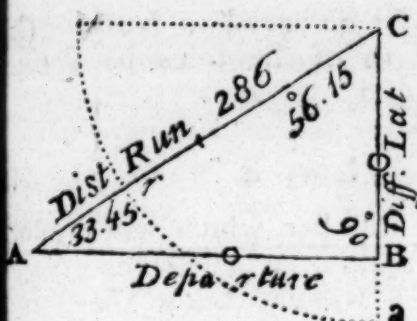
Difference of latitude and departure required?

A Ship from latitude $42^{\circ}.30'$ N. sails S W by W 286 miles. What latitude is she arrived at, and what departure hath she made?

TO PROJECT the FIGURE. R U L E.

Draw the meridian or difference of latitude, which is always North and South, then with a Chord of 60 degrees from C. describe an arc representing the quarter the ship sails in, on which arc set off the course the ship sails, viz SW by W. equal to $56^{\circ}.15'$ or 56 points from a. to r. thro' r. the place where it cuts the arc, draw the distance line C A. equal to 286 miles, from any scale of equal parts, then in manner as you would let fall a perpendicular from A. on C B draw the departure, then will the figure be projected

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Lat. failed from $42^{\circ}.30'N$
 Dif. lat. $158.9 \div 60 = 2 \quad 39 S.$

Lat. arrived in $39 \quad 51 N$

N. B. Through the whole of the projections of the figures in the various failings, the quarter the ship fails in should be the first thing drawn.

FIRST, BY CALCULATION.

Making the distance radius to find the diff. of latitude.

As radius $= 90^{\circ} = 0.00000$
 .. distance $= 286' = 2.45637$
 :: S. com. co. $33^{\circ}.45' = 9.74474$
 .. diff. lat. $158'.9 = 2.20111$

Making the distance radius to find the departure.

As radius $= 90^{\circ} = 0.$
 .. distance $= 286' = 2.45637$
 :: S. cour. $= 56^{\circ}.15' = 9.91985$
 .. departure $237'.8 = 2.37622$

Making the departure radius to find the diff. of lat.

As sec. co. cou. $33^{\circ}.45' = 1.91985$
 .. distance $= 286' = 2.45637$
 :: tan. co. cou. $33^{\circ}.45' = 9.82489$
 .. diff. lat. $158'.9 = 2.20111$

Making the departure radius to find the departure.

As sec. co. cou. $33^{\circ}.45' = 1.91985$
 .. distance $= 286' = 2.45637$
 :: radius $= 90^{\circ} = 10$
 .. depart. $= 237'.8 = 2.37622$

Making the diff. lat. radius to find the diff. of latitude.

As sec. cour. $56^{\circ}.15' = 1.74474$
 .. distance $286' = 2.45637$
 :: radius $= 90^{\circ} = 10$
 .. diff. lat. $158'.9 = 2.20111$

Making the diff. lat. radius to find the departure

As sec. cou. $56^{\circ}.15' = 1.74474$
 .. distance $= 286' = 2.45637$
 :: tan. cour. $56^{\circ}.15' = 10.17511$
 .. departure $237'.8 = 2.37622$

A GENERAL RULE to be observed in working by inspection, should the length of the sides be greater than the table will admit of.

R U L E.

Divide the sides by any number which will produce a quotient of each, to come within the table when greater, always observing, should you want to know the length of any particular side, you must multiply the required side by the same number you divided by, and it will give the true length of the side required.

SECOND BY INSPECTION.

From the difference of latitude and departure table

R U L E.

With the given course and distance seek in the table against which stands the difference of latitude and departure as required. Thus at the bottom of the table I find 5 points, or S W by W. and against the distance 286 stands 237.8 departure and 158.9 latitude as required.

Ans. Latitude in $39^{\circ} 51'$ N. departure 237.8 W.

C A S E II.

Course and difference of latitude given,
Distance run and departure required.

A ship sails NE by N. from $36^{\circ} 30'$ North latitude into $40^{\circ} 20'$ North. What distance hath she run and what departure hath she made?

$40^{\circ} 20' N$

Lat. from	40°. 20' N.
Lat. in	36. 30 N.
	3. 50
	60
	230 diff. lat.



FIRST BY CALCULATION.

Making the difference of latitude radius to find the departure and distance.

As radius = 90° = 0	As radius = 90° = 0
diff. lat. = 230 = 2.36173	∴ diff. lat. = 230 = 2.36173
T. cou. 33°. 45' = 9.82489	∴ sec. cou. 33°. 45' = 10.08015
depart. 153.7 = 2.18662	∴ distance 276.6 = 2.44188

SECOND, BY INSPECTION.

R U L E.

With the course and difference of latitude given, you will find against their proper columns the distance and departure required.

Thus at the top of the table I find 3 points equal NE by N. and against each side of 230 latitude I find 277 in the distance column, and 153.9 in the departure column as required.

Ans. Distance run 276.6 miles, and departure 153.7 miles.

CASE

C A S E III.

Difference of latitude and distance run given,
Course and departure required.

A ship from $26^{\circ}.21'$ South latitude, sails between the South and West 180 leagues, into the latitude $29^{\circ}.2'$ South. What is the course, and how far has she departed from the meridian?

Lat. in $29^{\circ}.02' S.$

Lat. from $26 \quad 21 \quad S.$

Diff. lat. $\begin{array}{r} 2 \quad 41 \\ 60 \end{array}$

$\underline{3)161 \text{ miles.}}$

$\underline{53.66 \text{ leagues..}}$



FIRST BY CALCULATION

Make dif. lat. rad. to find cour. | Make the dist. rad. to find de

As diff. lat. $= 53.661 = 8.27035$ | As rad. $= 90^{\circ} = 0$

$\therefore$ rad. $= 90^{\circ} = 10$ | $\therefore$ dist. $= 1801. = 2.255$

$\therefore$ dist. $= 1801. = 2.25527$ | $\therefore$ f. cou. $= 72^{\circ}.39' = 9.97$

$\therefore$ Sec. cou. $= 72^{\circ}.39' = 10.52562$ | $\therefore$ depart. $= 171.81 = 2.238$

SECOND BY INSPECTION.

R U L E.

With the distance and difference of latitude given, look in the tables, and adjoining to it stands the departure

which if less than the difference of latitude the course found at the top, but if greater the course is found at the bottom.

Thus with 180 the distance, and 53.66 the difference of latitude, in the table they are found to agree nearly their respective columns, over $6\frac{1}{2}$ points against which stands 172.3 the departure, which is as near this table will admit of.

Ans. Course S. $72^{\circ}.39'$ W. or WSW. $\frac{1}{2}$ W. nearly; departure 177.8 leagues, W.

C A S E IVth.

Difference of latitude and departure given,
Course and distance run required.

A ship from a port in latitude $18^{\circ}.40'$ N. is bound to a port in latitude $21^{\circ}.06'$ N. and her departure 108 leagues East. What is her course and distance to her desired port?

Lat. to $21^{\circ}.06'$ N.
Lat. from $18^{\circ}.40'$ N.

depar. 108 leagues.

$$\begin{array}{r} 2 \ 26 \\ 60 \\ \hline \end{array}$$



$$\begin{array}{r} 3 \\ 324 \text{ miles.} \end{array}$$

Diff. lat. 146 miles.

FIRST BY CALCULATION,

Take dif. lat. rad. to find the co.

As dif. lat. = 146 = 7.83565

rad. = 90 = 10

depar. = 324 = 2.51054

tan. cou. $65^{\circ}.45' = 10.34619$

Make dist. rad. to find the dist.

As f. cou. = $65^{\circ}.45' = 0.04012$

∴ depar. = 324 = 2.51054

∴ rad. = $90^{\circ} = 10.$

∴ dist. = 355.4 = 2.55066

N. B. Having

N. B. Having worked the three last cases by inspection from the points, I now make choice of giving one or two examples from the table of degrees,

SECOND BY INSPECTION.

R U L E.

With the given difference of latitude and departure seek in the table, against which you will find the distance, and the course will be found as in the last case.

Thus with $\frac{1}{2}$ of $146 = 73$ latitude, and $\frac{1}{2}$ of $324 = 162$ departure, I look in the table 'till they agree in their respective columns, which they do nearly over 66 degrees, against which stands 178 distance, which being doubled gives 356 nearly as by calculation.

Ans. Course N. $65^{\circ}.45'$ E. or NE by E. $\frac{1}{4}$ E. nearly distance 355.4 miles.

C A S E Vth.

Distance run and departure given,

Difference of latitude and course required.

A ship from $2^{\circ}.36'$ North latitude, sails between the South and East 280 leagues, and made 95 leagues Easting, What is her course, and what latitude is she in?



FIRST

FIRST BY CALCULATION.

Making the distance radius, to find the course and difference of latitude.

As distance = 280l. = 7.55284	As radius = 90° = 0
radius = 90° = 10	∴ distance = 280l. = 2.44716
∴ depart. = 95l. = 1.97772	∴ f.co.cou. = 70° 10' = 9.97344
f. course 19° .50' = 9.53056	∴ diff. lat. 263.4l. = 2.42060
90	3

o. course 70 10

6,0)79|0.2

Diff. lat. 13 10 S.
Lat. from 2 36 N.

Lat. in 10 34 S.

SECOND BY INSPECTION.

R U L E.

With the given distance and departure seek in the table among the degrees 'till their respective columns agree; adjoining to it stands the difference of latitude, which if greater than the departure the course is found top, but if less at bottom.

Thus with 280 the distance, and 95 the departure, they are found nearly to agree in their respective columns, under 20 degrees against which stands 263.1 latitude, which is as near as the table will admit of.

Ans. Course S. 19° .50' E. Lat. in 10° .34' south.

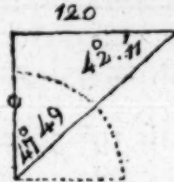
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CASE

C A S E VIth.

Course and departure given; distance run, and difference of latitude required?

A ship from $1^{\circ}.11'$ south latitude sails $NE\frac{1}{4}E$. until her departure is 120 leagues. I demand the distance run and the latitude arrived at?



FIRST by CALCULATION.

Making the distance radius to find the distance and difference of latitude.

As f. cou. $= 47^{\circ}.49'$	$= 0.13018$	As radius $= 90^{\circ}$	$= 0$
.. Depart. $= 120$ l.	$= 2.07918$	.. Dist.	$161.9 = 2.20936$
:: Radius $= 90^{\circ}$	$= 10.$	:: f. co. cou. $42^{\circ}.11'$	$= 9.8277$

Distance 161.9 l.	<u>2.20936</u>	.. Diff. lat. 108. 7	<u><u>2.0364</u></u>
			3

$$610)326.1($$

Diff. lat.	5.26 N.
Lat. from	1.11 S.

$$\underline{4.15 \text{ N.}}$$

SECOND by INSPECTION.

R U L E.

With the given course and departure look in the table of points, against which in their respective columns stand the distance and difference of latitude.

Th

Thus, with the course 48 degrees and 120 departure, against which in their respective columns is 162 distance, and 108.4 diff. of latitude.

Ans. Dist. run 161.91 *leag.* Lat. arrived, $4^{\circ}.15'$ N.

EXERCISING EXAMPLES IN PLANE SAILING.

A ship from the latitude of $5^{\circ}.20'$ S. sails SW by S. 320 miles; what latitude is she arrived at, and what departure has she made from the meridian?

Ans. Latitude arrived at $9^{\circ}.46'$ S. and she has departed 77.8 miles from the meridian.

A ship sails SW by S. from the latitude of 50° N. into the latitude of $49^{\circ}.08'$ N. what distance hath she sailed, and how far has she departed from the meridian?

Ans. Her distance sailed is 62.54 miles, and her departure from the meridian is 34.75 miles.

A ship from the latitude of $47^{\circ}.20'$ N. sails between the north and east 98 miles, and then finds herself in latitude $48^{\circ}.42'$ N; what course has she steered, and what departure hath she made?

Ans. Her course was N. $33^{\circ}.12'$ E. and her departure 3.66 miles.

A ship from latitude $48^{\circ}.22'$ N. sails between the north and west until her departure is 54 miles, and then finds herself in latitude $49^{\circ}.54'$ N; what course did she steer, and what distance has she run?

Ans. The course steered was NW by N. nearly, that is N. $33^{\circ}.22'$ W. distance 98.18 miles.

A ship from $32^{\circ}.25'$ north latitude, sails between the north and west 496 miles, until her departure is 412 miles; what course has she steered, and what latitude is she arrived at?

Anf. Her course steered was $N. 56^{\circ}.10' W.$ or NW by $W.$ and her latitude arrived at $37^{\circ}.01'$ north.

A ship from the latitude of $40^{\circ}.10' N.$ sails NE by $N\frac{1}{4}E.$ until her departure be 33 miles; I demand the distance sailed, and the latitude the ship is arrived at?

Anf. Her distance sailed 55.39 miles, and her latitude arrived at $40^{\circ}.54' N.$ nearly.

ON TRAVERSE SAILING.

DEFINITIONS and PRINCIPLES.

1st. A traverse is described by a ship's sailing on several courses.

2d. Resolving a traverse, is reducing several courses into one, and finding the course and distance, &c. of it, (when so reduced) by rectangled trigonometry.

RULES for delineating a TRAVERSE.

1st. Draw new meridians through the extremity of every course, (parallel to the first meridian); then lay off the course and distance as in plane sailing, and every course and distance will represent a plane sailing question.

2d. Lay

2d. Lay down the quantity of the angle, (after the first course is drawn between the point next to be laid down, and the point opposite the course last drawn,) and so proceeding till the whole is finished.

3d. Having a circle described and divided as the Mariner's Compass, you may draw the several courses parallel to the rhumbs in the compass, then lay off the distances; which being done, a line drawn from the place the ship departed from to the place she arrived at, is the distance; and the angle which this line makes with the meridian, is the direct course; the same to be understood in the two former methods.

C O R O L L A R Y.

Hence the difference between the point opposite the course last laid down, and the angle the next point makes, is the course drawn, if tending contrary ways; but their sum is the course when tending to each other.

DIRECTIONS for working TRAVERSES by the Table of Difference of Latitude and Departure.

1st. Draw columns for the courses and distances, northing, southing, easting and westing, as per table, in which write down each course and distance sailed.

2d. Look into the table of difference of latitude and departure for each course and distance, and agreeable hereto insert it in the traverse table, as you might have sailed either in the NE. NW. SE. or SW. quarters, and when you have finished the whole, add up the northing, southing, easting, and westing, according as you may have sailed.

3d. Should there be northing and southing (in the traverse table) subtract the less from the greater, as also do the like respecting the easting and westing, it will then give you the whole true difference of latitude and departure.

EXAMPLE in working TRAVERSES.

Suppose a ship sails on the following correct courses, (viz.) SW. 70', SSW. 46', then due south 50', and lastly, S by E. 42', required her whole true difference of latitude and departure?

Having drawn the traverse table, and wrote in it each course, (viz.) SW. 4 points or 45° distance 70', then SSW. 2 points or $22^{\circ}.30'$ distance 46'. &c. &c.—look into the table of difference of latitude and departure for 4 points or 45° , and against 70 in the distance column, you will find 49.5 latitude, and 49.5 departure, which insert in the table under the southing 49.5 for latitude, and under the westing 49.5 for departure. Again, seek for 2 points, or $22^{\circ}.30'$, and against 46' the distance you will have 42.5 lat. and 17.6 depart. which also place in the traverse table under southing 42.5 for lat. and under the westing place 17.6 for the depart. &c. &c.

N. B. Should any of your courses be due north, east, south, or west. in that case you place the distance sailed. if north, under the northing column, if south, under the southing column, &c, and when sailing in the NE. quarter, you must set the latitude under the northing, and the departure under the easting; but if sailing in the SW. quarter, you must place the latitude under the southing, and the departure under the westing columns, &c. &c. ever observing to place latitude either under the northing or southing columns; and departure under the easting or westing columns, according to the quarter of the compass which you may have sailed in.

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Courses corrected.	Points.	Diff.	N.ing.	S.ing.	E.ing.	W.ing.
SW.	4	70	---	49.5	---	49.5
SSW.	2	46	---	42.5	---	17.6
South.	0	50	---	50.0	---	---
S by E.	1	42	---	41.2	8.2	---
Diff. lat.				183.2	8.2	67.1
					Depart.	58.9

EXAMPLES in TRAVERSE SAILING.

A ship in the channel sets the Lizard NE. 4 leagues, then sails SW. 50 leagues, then SW. by S. 42, then S. 45, and lastly SSW. 56; what are the bearings and distance, and what latitude is the ship in, supposing her courses correct?

TO PROJECT the FIGURE..

R U L E.

Draw the meridian or north and south line, and with the chord of 60 degrees describe the quarter of the compass the ship sails in, on which from the meridian set off 45 degrees for the SW. course, and draw the distance line, and on it set off 54 leagues (4 leagues being allowed for the back bearings of the Lizard) which is the ship's place at the end of her first course: From this place draw a new meridian parallel to the first, and again with a chord of 60 degrees describe an arc in the quarter the ship sails in, and make the centre the ship's place when at the end of her first course) on which arc, from the meridian set off $33^{\circ}.45'$ for the SW by S. course, and

and draw the distance line, and on it set off 42 leagues, and it will be the ship's place at the end of her second course. Proceed to draw a new meridian as before, on which set off 45 leagues for the distance, as the ship sailed due fouth, it will be her place at the end of her third course; continue the fouth line for a new meridian, and sweep an arc (of 60 degrees from her place at the end of her third course) in the SW quarter, and set off $22^{\circ}.30'$ for the SSW. course, then draw the distance line, and on it set off 56 leagues, and it will be the ship's place at the end of her fourth and last course. Now to find the bearings and distance of the Lizard, draw a line from the Lizard to the ship's place, which line will be the true distance from the Lizard, and the angle it makes will be the bearing.

THE TRAVERSE TABLE.

Course corrected.	Points.	Dist. in leagues	N.ing	S.ing.	Ealt. ing.	W.ing.
SW.	4	54	—	38.2	—	38.2
SWbyS.	3	42	—	34.9	—	23.3
South.	0	45	—	45.	—	—
SSW.	2	56	—	51.7	—	21.4
				169.8		82.9
				Diff. lat.		Depart.

Mak. diff. lat. rad. to find cou.	Mak. dif. rad. to find the dif.
Leag.	
As diff. lat $= 169.8 = 7.77006$	As S cour. $= 26^{\circ}.01 = 0.35789$
.. Rad. $= 90^{\circ} = 10.$	.. Depart. $= 82.9 = 1.91855$
:: Depart. $= 82.9 = 1.91855$	:: Radius $= 90^{\circ} = 10.$
.. Tan. cour. $26.01 = 9.68861$	.. Dist. $= 189 = 2.27644$

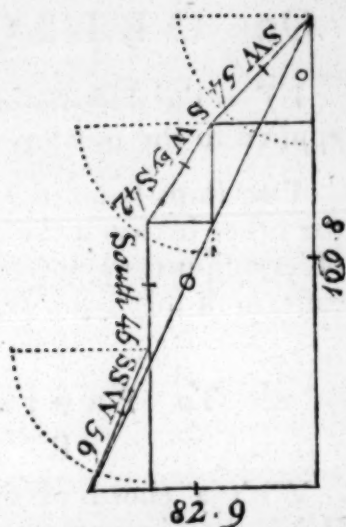
Leag.

Leag.
169.8
3

6,0)50,9 4

Diff. Lat. 8.29 S.
Lat. Liz. 49.58 N.

Lat. in 41.29 N.



Anf. The Lizard bears N. $26^{\circ}.01'$ E. distance 189 leagues, and the ship is in the latitude of $41^{\circ}.29'$ N.

A ship from latitude $24^{\circ}.32'$ N. sails on the following corrected courses, viz. SW by W. 45 miles, ESE. 50 miles, SW. 30 miles, and SE by E, 60 miles: What latitude is she arrived at, and what is her course and distance made good?

Anf. Her latitude arrived at $22^{\circ}.53'$ N. her course S. $30^{\circ}.49'$ E. distance 105.5 miles.

A ship from latitude $10^{\circ}.38'$ N. is bound to a port bearing SW by S. distance 282 miles, after three successive days of bad weather finds herself in latitude $3^{\circ}.58'$ N. and 120 miles to the eastward of her intended port: required her course and distance to the said port.

Anf. The course is N. $35^{\circ}.56'$ W. or NW by N $\frac{1}{4}$ W. nearly, distance 204.4 miles.

ON

ON OBLIQUE SAILING.

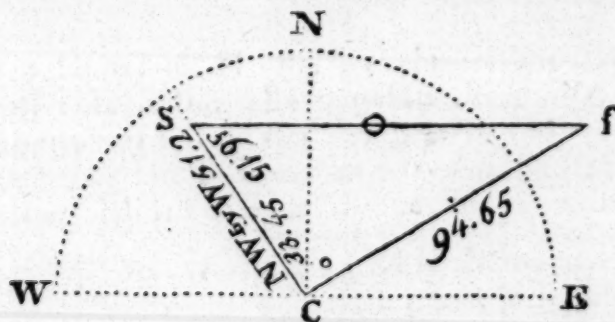
IT is the doctrine of oblique trigonometry, and it is applied to the measuring of inaccessible objects.

Two ships sailed from one port, one NW by N. $51^{\circ}.2'$, the other between the north and east $94^{\circ}.65'$, when by observation they were in one latitude: What was the eastermost ship's course, and the distance of the ships?

TO PROJECT the FIGURE.

R U L E.

With a chord of 60 degrees sweep the semi-circle WNE. let C represent the place from whence the 2 ships sailed, then will NW. be the north west, and NE. be the north east quarters; from N. towards W. in the north west quarter, set off $33^{\circ}.45'$, which is the westermost ship's course, draw the line CS. and on it, (from any scale of equal parts) set off $51.2'$ miles from C to S. her distance, then parallel to WCE draw Sf, and from C with 94.65 miles, from the same scale of equal parts used before, cut Sf at f in the north east quarter, (the two ships being in one latitude) then is Sf their true distance, and the $\angle NCF$ the eastermost ship's true course



As Et. most ship's dist. run $94.65 = 8\ 02388$

W. most ship's f. co. cou. $56^{\circ}.15 = 9.91985$

Wt. most ship's dist. run $51.2 = 1.70927$

Et. most ship's f. co. cou. $26\ 44 = 9.65300$

90

63.16 Et. most ship's course.

33.45

97.01 The $\angle$ both ship's make.

As Wt. most ship's f. co. course $56^{\circ}.15' = 0.08015$

Et. most ship's dist. run $94'.65 = 1.97612$

The $\angle$ both the ships make $97^{\circ}.01' = 9.99673$

Their distance $113 = 2.05300$

Ans. The eastermost ship's true course, N. $63^{\circ}.16'$ E.
and their true distance 113 miles.

A ship on a NE by N. course, saw a-head land bearing
W by N. after sailing 36 miles, it bore W by S. What
was its distance at each time of setting it?

Ans. Its distance at first observation was 66.52 miles,
and the second 86.91 miles.

Two ships part company at sea, one sails on a SE by S.
course, the other ENE. eight miles, at which time they
bore N by W. and S by E. What's their distance, and
the southermost ship's distance run?

Ans. Their distance asunder is 20.5 miles, and the
southermost ship's distance run was also 20.5 miles, it
being an isosceles triangle.

Two

Two ship's part company at sea, one sails SW by S. 36 miles, the other SSE. 29 miles: What's their bearings and distance?

Anf. They bore W $5^{\circ}.45'$ S. and E $5^{\circ}.45'$ N. distance 31.26 miles.

Sailing WNW. I saw two capes, one bore N. the other W by S. after three quarters of an hour's sail at 8 knots, the first bore ENE. and the other S by E. What's their bearings and distance.

Anf. They bore S. $41^{\circ}.20'$ W. and N. $41^{\circ}.20'$ E. distance 7.411 miles.

ON PLYING to WINDWARD.

IT is when a ship, vessel, &c. sails on various courses, owing to contrary winds, by means of which the mariner is obliged to steer different ways to get to windward; and it is the application of oblique trigonometry.

The wind at NNE. a ship is bound to a port bearing NE by E. distance 32 miles, proposes to reach her port at two boards, but can lie no nearer the wind than 60 points: What's the distance of each course?

R U L E.

With a chord of 60 degrees, sweep the circle NESW and let C represent the place of the ship in her first station, draw the NE by E. line CP equal to $56^{\circ}.15'$ from N. on which set off 32 miles from C to P, then from N to W, set off $22^{\circ}.30'$ equal to NNE. then will CW represent the wind; again from W towards the east and west each way, set off $6\frac{1}{4}$ points equal to $70^{\circ}.19'$, and draw CA and CB, and parallel to AC from P draw PB, then will the $\angle C$. be equal to her first course, and CB her first distance; also the $\angle B$. her second course, and BP her second distance.



As S $\angle$ B 39°.22' = 0.19772	As S $\angle$ B 39°.22' = 0.19772
.. CP 32' = 1.50515	.. CP 32' = 1.50515
:: S $\angle$ P 104°.04' = 9.98678	:: S $\angle$ C 36°.34' = 9.77507
.. CB 48.94 = 1.68965	.. BP 30.06 = 1.47794

Anf. She must sail E $\frac{1}{4}$ S. 48.94 miles with her larboard tacks on board; NW $\frac{1}{4}$ W. 30.06 miles on her starboard tack.

Wind SW by W. a ship sails 20'.9 on each tack, and gets 16 miles to windward: How near the wind did she lay, and what was her course; her first was with the larboard tacks on board?

Anf. She sailed within 6 points of the wind on each tack, viz. her first course was NW by W. with her larboard tacks on board, and her second course S by E with her starboard tack.

Wind SSW. being on my starboard tack, I met a ship that had sailed from the port I was bound to NE by E. 120 miles; the next day I fell in with another ship, that had run 164 miles with the wind one point abaft the beam, from the same port: What was my course and distance between meeting the two ships, allowing the wind the whole time to be SSW.?

Anf. My course was S 31°.45'E. distance 116 miles

Wind S by W. a ship sails within 7 points on her larboard tack 25'.5 miles, then tacks and makes her way good at 6 $\frac{1}{2}$ points from the wind, and falls in with an island that bore SW by W. from the port she sailed from: What is the distance of the island from the port and place of tacking?

Anf. The distance of the island from the port was 13.63 miles, and from the place of tacking 16.06 miles

On

ON CURRENT SAILING.

A current is a stream by means of which all bodies moving thereon are compelled to submit to its motion, and it often alters a ship's apparent course; but should a ship sail in a direct course with the setting of a current, it will accelerate her sailing by just so much as the drift of the current; or if she sails in a direct course opposite to the current's setting, it will retard her sailing by just so much as the current's drift, without altering her course in either of the above cases; but should she sail athwart a current, it then alters her apparent course and augments or lessens her velocity. This sailing is the application or doctrine of plane triangles.

To find the drift and setting of Currents.

Take a boat at some little distance from the ship, and with a heavy iron pot or loaded kettle, with a rope fastened to the boat's stern, let it sink into the sea, 80, 90, or 100 fathoms deep, by which means the boat will ride as steady almost as if at anchor, then heave the log and it will give the miles which the current sets per hour, and as the log bears it will shew the current's setting.

E X A M P L E.

A current runs West $6\frac{1}{2}$ knots per hour, and a ship sails East $6\frac{1}{2}$ knots per hour. What is her compound motion?

L 2

West

$$\begin{array}{r} \text{West } 6.5 \\ \text{East } 6.5 \\ \hline \end{array}$$

Anf. the Ship continues in the same place.

A ship sails NNE. 8 knots per hour, in a current setting SSW. $4\frac{1}{2}$ per hour. What is her compound motion,

$$\begin{array}{r} \text{Ship sails NNE. 8 knots.} \\ \text{Current SSW. } 4\frac{1}{2} \\ \hline \end{array}$$

Anf. the ship's motion $3\frac{1}{2}$ knots per hour, NNE.

A ship in a light breeze of wind sails 3 hours SW 4 knots per hour, at which time they discovered the current had set NE. $6\frac{1}{2}$ knots per hour. What is her course and distance.

$$\begin{array}{r} \text{Ship sails} \\ \text{SW. 3 hours,} \\ \quad 4 \text{ knots.} \\ \hline 12 \text{ knots SW.} \end{array}$$

$$\begin{array}{r} \text{Current sets 3 hours.} \\ \text{NE. } 6\frac{1}{2} \\ \hline \text{NE. } 19\frac{1}{2} \text{ knots.} \\ \text{SW. 12 knots.} \\ \hline \text{NE. } 7.5 \end{array}$$

Anf. She dropped astern NE. 7.5 miles.

A ship sails 4 hours SE. at $7\frac{1}{2}$ knots in a current setting the same way $2\frac{3}{4}$ knots per hour. What is the compound motion?

Ship

Ship sails.
SE. $7\frac{1}{2}$ knots per hour
for 4 hours.

30 SE.

current sets SE. $2\frac{1}{4}$

4

current 11 SE
ship 30 SE

4)41

10 $\frac{1}{4}$

Ans. her compound motion is $10\frac{1}{4}$ knots per hour,
and her course is SE. 41 miles.

A ship crossing the mouth of an haven into which
the tide sets E by N. sails from a buoy NNE. 8 miles,
and falls in with another buoy bearing NE. from the
first. What is the drift of the current and distance
of the buoys?

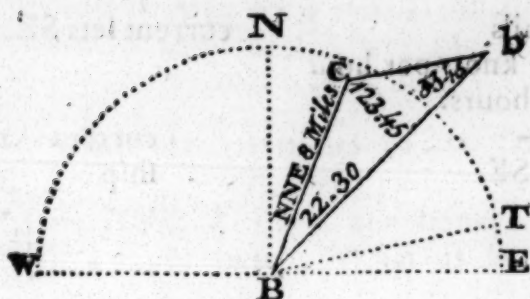
To PROJECT the FIGURE.

R U L E.

With a chord of 60 degrees sweep the semi-circle
VNE. and let B represent the buoy sailed from, set
off from N. the ship's course NNE. equal to $22^{\circ}.30'$
and draw the line B C. equal to 8 miles; from N.
set off the two buoys bearing NE equal to 45° and
draw B'b. then from E. set off E by N. equal to
 $10^{\circ}.15'$ and draw B T. and parallel thereto draw
b. and the figure is formed.

L 3

A



$$\begin{array}{lcl}
 \text{As f. } \angle b = 33^{\circ}.45' = 0.25526 & | & \text{As f. } \angle b = 33^{\circ}.45' = 0.25526 \\
 \therefore BC = 8' = 0.90309 & | & \therefore BC = 8' = 0.90309 \\
 \therefore \text{f. } \angle B = 22^{\circ}.30' = 9.58284 & | & \therefore \text{f. } \angle C = 123^{\circ}.45' = 9.91985 \\
 \therefore Cb = 5'.51 = 0.74119 & | & \therefore Bb = 11'.97 = 1.07820
 \end{array}$$

Ans. the currents drift 5.51 miles, and the distance of the buoys 11.97 miles.

A ship sails 12 hours South 8 knots per hour, in a current setting East $3\frac{1}{2}$ per hour. What is her course and distance corrected?

Ans. Her course S. is $23^{\circ}.38'$ East distance 104 miles.

A ship from $20^{\circ}.13'$ South, sails East by log 60 miles athwart a current setting North, when by observation she was $15^{\circ}.21'$ South. What did the current set her up, and what is her rational course and distance?

Ans. The current set her up 292' to the Northward and her rational course is East $25^{\circ}.41'$ North, distance 673.7 miles.

A ship

A ship sails 12 hours SSW. $\frac{1}{2}$ W. 9 miles per hour, athwart a current that sets S by E. 4 miles per hour. What is her course and distance.

Ans. Her true course is S. $16^{\circ}.16'$; ~~W.~~ distance 148.3 miles.

MERCATORS SAILING.

By MERIDIONAL PARTS.

D E F I N I T I O N.

It is the application of rectangled trigonometry, with this observation, that the meridional difference of latitude bears the same proportion to the difference of longitude, as the proper difference of latitude does to the departure; and that the angle made by the continuation of the distance, 'till it cuts the difference of longitude, is equal to the complement of the course.

NAUTICAL OBSERVATIONS.

C A S E Ist.

The longitude of two places given, the difference of longitude required?

RULE.

R U L E.

If the longitudes are of the same name, their difference is the difference of longitude required of the like name—but if the longitudes have different names, their sum gives the required difference of longitude, and if this exceeds 180° take it from 360° and the remainder is the required difference of longitude.

What is the difference of longitude between the Lizard and Gibraltar?

Lizard's long. $5^\circ. 15' \text{ W.}$

Gibraltar's long. $5^\circ. 22' \text{ W.}$

Ans $0^\circ. 7'$ miles.

What is the difference of longitude between Portsmouth and Minorca?

Portsmouth's long. $1^\circ. 6' \text{ W.}$

Minorca's long. $3^\circ. 49' \text{ E.}$

Diff. of long. $4^\circ. 55'$ = 295 miles.

What is the difference of longitude between Bencoolen in the East-Indies and Porto-Bello in America?

Ben-

Bencoolen's long. $102^{\circ}.00'$ E.

Porto-Bello's long. $79 \quad 50$

$181 \quad 50$

360

Difference of long. $178 \quad 10$

C A S E IId.

The longitude of one place and difference of longitude given, the longitude of the other required?

R U L E.

If the given longitude and difference of longitude have different names, their difference is the longitude required, and is of the same name with the greater; but if the given longitude and difference of longitude are of the same name, their sum is the required longitude of the same name; and if their sum is greater than 180° its remains from 360 is the required longitude of a contrary name with that of the given place.

A ship from the Lizard sails Westward 'till her difference of longitude be 350 miles. What longitude is she in?

Lizard's long. $5^{\circ}.15'$ West.

Diff. of long. $350 \div 60 = 5 \quad 50$ W.

Long. in $11 \quad 05$ W.

A ship

A ship from $1^{\circ}.30'$ east longitude, sails westward till her difference of longitude is 210 miles: What longitude is she in?

$$\begin{array}{l} \text{Longitude sailed from} = 1^{\circ}.30' \text{ E.} \\ \text{Diff. of longitude. } 210' \div 60 = 3 \quad 30' \text{ W.} \end{array}$$

$$2. \quad 0' \text{ W.}$$

A ship from longitude $140^{\circ}.24'$ west, sails westward until she differs her longitude $46^{\circ}.10'$ west: What longitude is she arrived in?

$$\begin{array}{l} \text{Longitude left} \quad 140^{\circ}.24' \text{ W.} \\ \text{Diff. of longitude} \quad 46 \quad .10' \text{ W.} \end{array}$$

$$186 \quad .34$$

$$360$$

$$\text{Longitude in} \quad 173 \quad .26 \text{ east.}$$

N. B. As the ship has crossed the opposite meridian, she is consequently come into a longitude of a different name.

C A S E I I I.

Latitude and longitude of two places given; their bearings and distance required.

What's the course and distance from the Lizard to Lisbon?

To

TO PROJECT the FIGURE.

R U L E.

Sweep the semi-circle, and let *l* represent the Lizard, from which draw the meridian, and on it (from any scale of equal parts) set off from *l* to *M* the meridional diff. of latitude 948' south; from *M*, at right angles to *lM*, draw *MD*, and on it set off the difference of longitude 235 west from *M* to *D*, then draw the line *lD*; again, from *l* to *P*, set off the proper difference of latitude 675. from which draw *PL* parallel to *MD* to cut *lD* in *L*, then will the angle made at *l* be the course, and *lL* the true distance.

Lizard's lat.	49° .57' N. = 3470	Lizard's long.	5° .15' W.
Lisbon's lat.	38 .42 N. = 2522	Lisbon's long.	9 .10 W.
	<u>11 .15</u>	Mer. diff. lat.	<u>3 .55 W.</u>
	60		60
Prop. diff. lat.	<u>675</u>	Diff. long.	<u>235 W.</u>

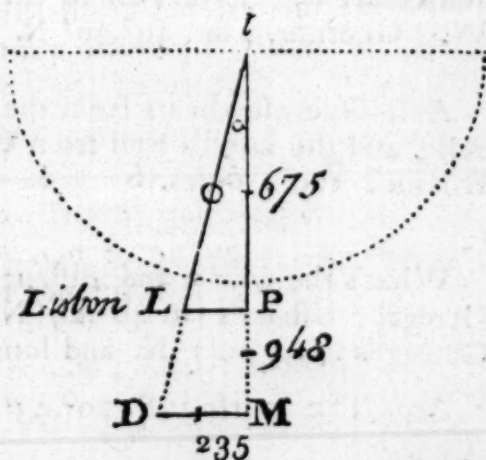
lM Meridional diff. of latitude.

MD Difference of longitude.

lP Prop. difference of latitude.

lL The departure.

lD The distance.



Making

Making M. D. Lat. Radius.	Making Diff. Lat. Radius
As M. D. L. = 948' = 7.02319	As Rad. = 90°00 = 0.
.. Radius = 90°00 = 10.	.. dif. lat. = 675 = 2.82930
:: Diff. long. = 235' = 2.37107	:: sec. cou. = 13°55 = 10.01290
<u>Tang. course 13°55' = 9.39426</u>	<u>Distance 695.4 = 2.84222</u>

Anf. The course is S. 13°.55' W. or S by W 2°40' W
Distance 695.4 miles.

What is the bearings and distance of Dunnose and Plymouth. Dunnose lat. 50°.34' N. long. 1°.16' W. and Plymouth lat. 50°.22' N. and long. 4°.16' W.

Anf. Dunnose bears from Plymouth N. 83°.58' E. and Plymouth from Dunnose S. 83°.58' west. Distance 114.2 miles.

What's the bearings and distance of the Land's End and Guernsey; Land's End's lat. 50°.06 N. long. 6°. W. Guernsey's lat. 49°.30' N. and long. 2°.47' W.

Anf. Guernsey bears from the Land's End S. 73°. east; and the Land's End from Guernsey N. 73°.49' Distance 129.2 miles.

What's the course and distance from Ushant to Ortegal; Ushant's lat. 48°.29' N. long. 5°.05' W. C Ortegal's lat. 43°.47' N. and long. 7°.39 west?

Anf. The course is S. 20°.43' W. Dist. 301.5 mi

C A

Distance
p

C A S E IIId.

Course, distance, and latitude given; difference of latitude, departure, and difference of longitude required?

A ship from the Lizard, whose lat. is $49^{\circ}.57'$ N. and long. 5.14 W. sails WSW $\frac{1}{2}$ W. 214 miles; what is her lat. and long. arrived at, and how far has she departed from the meridian?

Anf. She is in lat. $48^{\circ}.55$ N. and long. $10^{\circ}.30'$ W. and has departed from the meridian 204.8 miles.

C A S E IIIId.

The course and difference of lat. given; distance and difference of long. required?

A ship from a Cape in $40^{\circ}.21'$ south lat. and $179^{\circ}.20'$ west long. sails S W by W. into the lat. of $42^{\circ}.36'$. How far did she sail, and into what longitude?

Anf. She sailed 243.5 miles, and long. $176^{\circ}.11'$ east.

C A S E IVth.

Course and departure given; distance, difference of lat. and difference of long. required?

A ship sails from $36^{\circ}.30'$ north, and $1^{\circ}.20$ east long. sails SSW. until her departure is 112 miles: How far did she sail, and into what lat. and long.?

Anf. She sailed 292.6 miles into the lat. of $32^{\circ}.00'$ north, and long. $00^{\circ}.55\frac{1}{4}$ west.

C A S E Vth.

Distance and difference of latitude given; course, departure, and difference of longitude required.

M

A ship

A ship from $41^{\circ}.15'$ north lat. and $26^{\circ}.18'$ east long. sails 85 miles between the north and east, making 64 difference of lat. What is the course and departure, with lat. and long. arrived at?

Ans. Her course is N. $41^{\circ}.09'$ east. Her departure 55'.93 miles; lat. $42^{\circ}.19'$ N, and long. $27^{\circ}.32'$ E.

C A S E VIth.

Distance and departure given; course, difference of lat. and difference of long. required.

A ship from 40° south lat. and $15^{\circ}.21'$ east long. sails between the south and west $120'$, making $80'$ departure: What is her course, difference of lat. and difference of longitude.

Ans. Her course south $41^{\circ}.49'$ west; difference lat. 89.43 , and difference of long. 104.7 miles.

C A S E VIIth.

Course, difference of long. and one lat. given; distance, departure, and difference of lat. required?

A ship from $26^{\circ}.12'$ south lat. and $17^{\circ}.21'$ W. long. runs SE by E and makes $67'$ east long. What is her distance, departure, and lat. arrived at?

Ans. Her distance run 72 miles, her departure 59.86 miles, and lat. arrived $26^{\circ}.52'$ south.

C A S E VIIIth.

Difference of lat. and departure given; course, distance, and difference of long. required.

A ship

A ship from $41^{\circ}.21'$ north lat. and $89^{\circ}.6'$ east long. sails between north and east, making $72'$ northing, and $51'$ easting: What is her course and distance, and **lon.** arrived at?

Ans. Her course N. 36.52 E. or NE by $N\frac{1}{4}$ E. nearly, distance 90.01 miles, and long. arrived at $90^{\circ}.19$ east.

A ship from $56^{\circ}.15'$ north lat. and 179 degrees east long. sails NE by E. 29 miles, then NNE. 36 miles, then ENE. 48 miles: What is her course and distance made good, with the lat. and long. arrived at, supposing her courses to be correct?

Ans. Course north $50^{\circ}.31'$ east, distance 106.6 miles, lat. arrived $57^{\circ}.23'$, and long. $178^{\circ}.30'$ west.

A ship from a port in lat. $50^{\circ}.25'$ north, and long. $4^{\circ}.20'$ west, is bound to a port whose lat. is $36^{\circ}.58'$ north, and long. $8^{\circ}.45'$ west, then sails on the following corrected courses, (viz.) SW by W. $100'$, then W by S. $107'$, then SW. $120'$, then WSW. $80'$, then SW by S. $109'$ then south $70'$. Required her course and distance to her intended port; also her course and distance made good upon her several courses steered, with her lat. and long. arrived at; and what course she must now steer, and how far to gain her intended port?

Ans. The course to her intended port is south $13^{\circ}.16'$ west, distance 829.1 miles. The course made good at the end of her different courses steered is south $49^{\circ}.07'$ west, distance 538.6 miles. Her lat. and long. arrived at, is $44^{\circ}.33'$ north lat. and $14^{\circ}.23'$ west long. and she must steer south $25^{\circ}.31'$ east, 503.7 miles to arrive at her intended port.

TO CONSTRUCT
A MERCATOR'S CHART,
FOR ANY VOYAGE WHATEVER.

E X A M P L E.

SUPPOSE a ship sails from the latitude of 51 degrees north, is bound to a port that lies in the latitude of 36° north, and it is necessary to make the chart consist of 11 degrees west longitude, it is required to draw a chart for it.

R U L E.

1st. Draw AQ, or an east and west line to represent a parallel of the equator, and at right angles thereto from Q draw QM, to represent the meridian of some known place, as London, Paris, Madrid, &c. whose longitude is known.

2d. Observe from the meridional parts of the greatest latitude, subtract the meridional parts answering to the lesser latitude, and it will give the bounds of the chart, north and south. Again, from the meridian set off on the equator the number of degrees you have occasion for either east or west; make use of any convenient scale of equal parts, and from 51° to 36° on the meridian, set off 1251 miles equal to the meridional parts of 51° less 36°, and draw MQ, which will be the bounds of the chart from north to south.

3. Again, take the meridional parts of 36 degrees from the meridional parts of 37 degrees, and set off their difference upon the meridian from 36 to 37 degrees (which is per table 75) then take the meridional parts

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times
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the rig
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of 36° from the meridional parts of 38° . and set off their difference (which is per table 150) upon the meridian from 36 to 38, and in like manner proceed to set off every degree of latitude the chart contains till the whole is done; but should the degrees be required to be divided into minutes, the meridional parts for such must be taken and set off as above.

4th. Take 60 in the compasses, and with one foot in Q, the meridian of London, set off towards A as many times as you have occasion for degrees of longitude, as 11, (but observe, if the chart was to contain any east longitude, you must set it off from the meridian towards the right hand side also); then from each of these parts, draw parallel lines to the meridian, which will be the bounds of the chart east and west.

5th. Having set off as many parallels as the chart is to contain, take from the table of latitude and longitude of places, the latitude and longitude of every particular place contained within the bounds of the chart; now to find any particular place in the chart, draw (with a black lead pencil) a parallel line along its latitude, and another along its longitude, their intersections will represent the place upon the chart; in like manner may every place within the bounds of the chart be laid down: Hence the particular points of a sea coast being formed as above, lines properly drawn from place to place, will form the out lines of that sea coast.

N. B. In like manner, or on the same principles, may any chart be drawn, whether it contains north or south latitude, or both; east or west longitude, or both.

A TABLE of MERIDIONAL PARTS,

From 36 to 51 Degrees, for the readier
drawing the CHART.

Degrees.	M. Parts Miles.		Degrees.	M. Parts Miles.
37° less 36	75	or thus	Fr. 36 to 37	74
38 — 36	150		37—38	75
39 — 36	227		38—39	77
40 — 36	305		39—40	78
41 — 36	384		40—41	79
42 — 36	464		41—42	80
43 — 36	545		42—43	81
44 — 36	628		43—44	83
45 — 36	712		44—45	84
46 — 36	798		45—46	86
47 — 36	885		46—47	87
48 — 36	974		47—48	89
49 — 36	1064		48—49	90
50 — 36	1156		49—50	92
51 — 36	1251		50—51	95

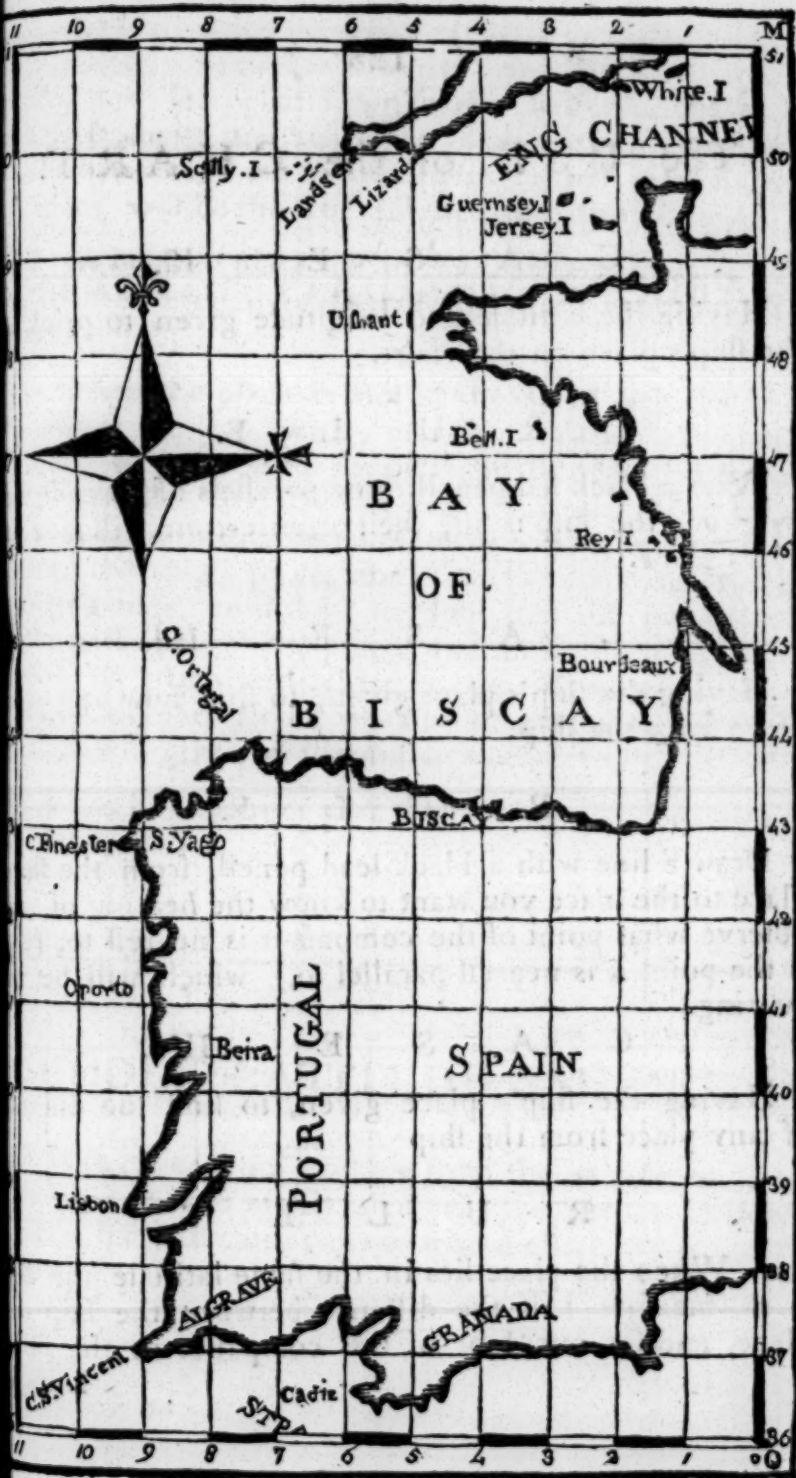
The CHART.

TS,

r

S

HART.



The USE of the CHART.

C A S E Ist.

Having the latitude and longitude given to prick off the ship's place on the chart.

R U L E.

With a black led pencil draw parallels of latitude and longitude the ship is in, their intersection will give the ship's place.

C A S E IId.

Having the ship's place given, to find how any place bears from the ship.

R U L E.

Draw a line with a black lead pencil, from the ship's place to the place you want to know the bearing of, and observe what point of the compass it is nearest to, (that is the point it is nearest parallel to,) which will be the bearing.

C A S E IIId.

Having the ship's place given, to find the distance of any place from the ship

R U L E S.

1. When the place lies in the same latitude the ship is in, measure half the distance between the ship and place, and set one foot of the compasses in the ship's latitude

itude, and see what latitude this half distance will reach both above and below it; then the difference of latitude between these two latitudes turned into miles, leagues, will be the true distance as required.

2d. When the place lies in the same longitude as the ship, their difference of latitude will give the true distance.

3d. When the place is not in the same latitude and longitude as the ship, with a pair of compasses take their difference of latitude in degrees and minutes from the equator parallel, and lay the edge of a ruler over both places, then with this distance in the compasses put one foot into the ship's place, and slide the compasses along the ruler's edge, until the other foot cuts the parallel of latitude passing thro' the place, and measure the distance between its place and where it cuts the parallel, then apply this distance to the equator or graduated parallel, and that will give you the distance required.

N. B. In like manner may the bearing and distance of places be found.

MIDDLE LATITUDE SAILING.

IT is so called from working from the middle to two latitudes; and it is mostly used near the line or in low latitudes, but Mercator's every where else.

When the bearings and distance of any two places are required, the proportion by middle latitude is thus:

$$\begin{array}{l} \text{As diff. lat.} \\ \text{.. S. co. mid. lat.} \\ \text{:: Diff. long.} \\ \text{.. T. bear. or course} \end{array} \left. \vphantom{\begin{array}{l} \text{As diff. lat.} \\ \text{.. S. co. mid. lat.} \\ \text{:: Diff. long.} \\ \text{.. T. bear. or course} \end{array}} \right\} \text{or thus, } \left\{ \begin{array}{l} \text{As diff. lat.} \\ \text{.. Radius} \\ \text{:: Departure} \\ \text{.. T. bear. or course} \end{array} \right.$$

The distance is found by plane sailing, but the departure thus.

$$\begin{array}{l} \text{As Radius} \\ \text{.. Diff. long.} \\ \text{:: S. co. mid. lat.} \\ \text{.. Departure} \end{array}$$

*** Lastly, to find the difference of longitude, it thus:

$$\begin{array}{l} \text{As f. co. mid. lat.} \\ \text{.. Departure} \\ \text{:: Radius} \\ \text{.. Diff. long.} \end{array} \left. \vphantom{\begin{array}{l} \text{As f. co. mid. lat.} \\ \text{.. Departure} \\ \text{:: Radius} \\ \text{.. Diff. long.} \end{array}} \right\} \text{or thus, } \left\{ \begin{array}{l} \text{As f. co. mid. lat.} \\ \text{.. Distance} \\ \text{:: S. course} \\ \text{.. Diff. long.} \end{array} \right.$$

C A S E Ist.

The latitude and longitude of two places given; the bearings and distance required?

What is the bearings and distance from the Lizard Maderia?

Liz. $49^{\circ}.58'$ Long. Liz. $5^{\circ}.15'W.$ Lat. Liz. $49^{\circ}.58'N.$
 t. Mad. $32^{\circ}.38'$ Long. Mad. $17^{\circ}.06'W.$ Lat. Mad. $32^{\circ}.38'N.$

17 .20
60

11 .51
60

$\frac{1}{2}$ 82 .36

lat. 1040

D. long. 711

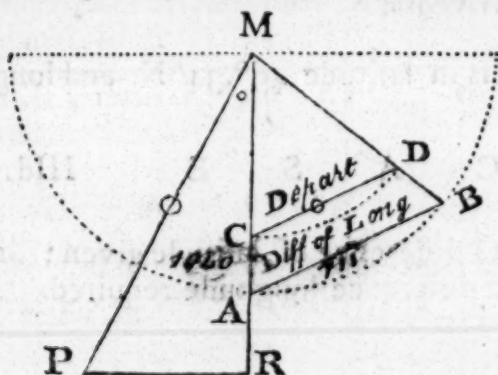
Mid. lat. 41 .18
90

Co. mid. lat. 48 .42

To PROJECT the FIGURE.

R U L E.

Draw the meridian MR. and from M, with 90 degrees off the line of fines sweep an arc, upon which set from A to B 711, the difference of longitude; then draw MB again from M, describe another arc equal to co. middle latitude off the line of fines, (viz.) $48^{\circ}.42'$, the distance it measures from C to D, will be the departure; then from M, set off upon the meridian the difference of latitude (in like manner as in a plane fail-question) 1040 miles, and from R, (making a right angle at R,) set off the length CD, the departure from P, and draw MP the distance line; then will the angle RMP be equal to the course, and MP the distance.



As

$$\begin{array}{l|l}
 \text{As diff. lat.} = 1040 = 6.98297 & \text{As rad.} = 90^\circ = 0. \\
 \text{.. f.co.m.lat. } 48^\circ.42' = 9.87579 & \text{.. D. lat.} = 1040 = 3.017 \\
 \text{:: D. long.} = 711 = 2.85187 & \text{:: f.cou.} = 27^\circ.11' = 10.050 \\
 \hline
 \text{.. t. cour.} = 27^\circ.11' = 9.71063 & \text{.. Dist.} = 1169 = 3.067
 \end{array}$$

Ans. The course is south 27.11 west distance 1169 miles.

What's the course and distance from the River Plate whose lat. is 36° south, and long. $57^\circ.40'$ west, to the Island of St. Helena, whose lat. is $15^\circ.55'$ south, and long. $5^\circ.49'$ west.

Ans. The course is north $66^\circ.42'$ east, distance 3067 miles.

C A S E IIId.

Course and distance given; latitude, departure, and difference of longitude required.

A ship from $50^\circ.40'$ north latitude, and $40^\circ.25'$ west longitude, sails SW by W. 120 miles: What's the lat. and long. arrived at?

Ans. She is in latitude $49^\circ.34'$ N. and long. $42^\circ.01'$ W.

C A S E IIIId.

Course and difference of latitude given; distance, departure, and difference longitude required.

A

A ship from $47^{\circ}.30'$ N. lat. and $1^{\circ}.26'$ west longitude, sails NE by E, into $48^{\circ}.45'$ north latitude, how far hath she sailed, and what's her longitude arrived at?

Ans. She sailed $135'$ into longitude $1^{\circ}.22'$ east.

C A S E IVth.

Course and departure given; distance, difference of lat. and difference of longitude required.

A ship from $51^{\circ}.12'$ south latitude, and $00^{\circ}.26'$ east longitude, sails NW by N. making 85 miles departure: What is her distance run, with latitude and longitude arrived at?

Ans. Distance run is 153 miles: Her latitude is $49^{\circ}.05'$ south, and longitude $1^{\circ}.47'$ west.

C A S E Vth.

Distance and difference of latitude given; course, departure, and difference of longitude required.

A ship from $17^{\circ}.20'$ north latitude, and $5^{\circ}.06'$ east longitude, sails between the south and west 105 miles into $16^{\circ}.30'$ north latitude: What is her course and longitude arrived at

Ans. Her course is south $61^{\circ}.34'$ west, longitude in $3^{\circ}.29'$ east.

C A S E VIth.

Distance and departure given; difference of latitude and difference of longitude required?

A

N

A ship

A ship from $21^{\circ}.30'$ south latitude, and $1^{\circ}.02'$ west longitude, sails 105 miles between the south and east making 87.5 miles departure : What is the course, with latitude and longitude arrived at ?

Ans. Her course is south $56^{\circ}.27'$ east, and she is in latitude $22^{\circ}.28'$ south, and longitude 32 miles east.

C A S E VIIth.

The difference of latitude and depart. given ; course distance and difference of longitude required.

A ship from the latitude of 46° . north, and longitude $21^{\circ}.37'$ east, sails between the south and west into the latitude of 44° . north, making 79 miles departure. What's her course, distance, and longitude arrived at ?

Ans. Her course is south $33^{\circ}.22'$ west, distance 143 miles, and she is in longitude $19^{\circ}.45'$ east.

DIRECTIONS FOR SURVEYING.

C A S E Ist.

To survey a harbour by observations on the water.

R U L E S.

1st. Moor two buoys at commodious stations and measure their distance ; from each station take the bearings of the most remarkable objects round the harbour near the water side, or erect station staves ;

Set off on your paper the situation and distance of the two stations, and the bearings of the objects from the stations; thro' the intersections of their bearings trace the coast line from station to station, then ornament it with a sketch of the appearance of the country; be sure that all the bearings are corrected by the variation of the compass.

21. Let the soundings at low water be marked with small figures, the time of high water on full and change days in Roman figures, and the setting of tides, currents, or eddies, by darts with their points the way they set; also, insert anchors in good anchoring ground.

3d. The common instrument used in surveying is the theodolite or azimuth compass.

N. B. When a harbour has turnings in it so extensive, that all its principal points cannot be seen at two stations, moor as many buoys as are necessary, noting their bearings and distances, and draw them (on your paper) in manner of a traverse; then take the bearings of the principal points, or objects from any two of them, whose bearings and distance are known, taking care that the object forms an angle with the two buoys of more than six degrees, for when lines lie very oblique, their intersections are not so easily or truly ascertained.—Again, if there should be a bar, shoal, sand, &c. each should be taken by rowing round it, noting the course, distance, and soundings, and insert them in the plan.

C A S E IId.

To survey a harbour by observations on the land.

R U L E S.

1st. Fix station staves at the most conspicuous and remarkable points and bends of the shore.

2d. Choose a spot of level ground, on which measure with great exactness a base of a convenient length, from the extremes thereof observe the bearings of each object.

3d. If any of those objects should not make an angle of more than six degrees, or if the harbour is too large to be taken from one base, fix on another level space, on which measure out a base from whose extremes the limits of the first base may be seen, or one limit and a station staff whose bearing was observed from that limit; then proceed in taking the bearings of the remaining objects or staves.

4th. More bases may be measured if necessary, regard being had to the above directions; the distance from the limit of one base to that of the other base is easily known by trigonometry.

5th. If particular parts cannot be viewed from any of the stations, go round the parts, make sketches thereof, and insert them in their proper places in the general draught.

6th. If

6th, If hills, trees, houses, &c. intervene, the distance from each station next that object to it, may be known by trigonometry.

C A S E III.

To take a draught of a sea coast by sailing along it.

R U L E S.

1st. Bring too, or cast anchor at a convenient place to view the principal points, head lands, &c. take their bearings, and make a rough sketch of the appearance of the coast.

2d. Sail in a direct line to another such station, noting the course and distance, during which time draw a more correct sketch of the coast.

3d. From the second station observe the bearings of the same head lands, &c. as before; and if required, more stations may be obtained the same way,

4th. Map the observations as before directed.

5th. Against each part of the course distinguish the appearance of rocks, windmills, cliffs, highlands, lowlands, sandhills, castles, &c.

6th. Express currents, eddies, anchorage, &c. as before.

N 3

7th, Draw

7th. Draw a double line through dangerous sands, &c. and the most remarkable things on shore, or if possible, two remarkable things in a direct line, that the channel through them may be known, by which marks dangerous parts may be avoided.

N. B. If you want to copy a draught, divide the whole into exact squares with a black lead pencil, then draw on your paper an equal number of squares, in such proportion as you want your draught, either exact, larger or smaller, as one half, one third, one fourth, &c. in each of the squares on your paper draw by the eye all things similar to the squares on the draught, 'till the whole is copied; then rub out the black lead pencil lines with India rubber or bread.

On finding the APPARENT and TRUE ALTITUDES of the SUN and MOON'S CENTRES; also the APPARENT and TRUE ALTITUDE of a FIXT STAR, with the APPARENT DISTANCE of the SUN and MOON'S CENTRES, by OBSERVATIONS taken at Sea.

DEFINITIONS and PRINCIPLES.

1st. HORIZON, is that circle which terminates the view of an observer upon the surface of the sea or earth.

2d. APPARENT

2d. **APPARENT ALTITUDE** of the sun, moon or star, is an arc of an azimuth circle, as it appears, or as observed or measured between the horizon and the object's centre, allowance being made for semi-diameter, dip and augmentation.

3d. **APPARENT DISTANCE** between the sun and moon, or the moon and a star, is the distance which they appear, or are observed to have, between their centres.

4th. **LIMB** of the sun or moon, is the external edge or any point or part of their circumference.

5th. **APPARENT SEMI-DIAMETER** of the sun or moon, is the half of their diameter, or the distance between their centre and the limb, as observed or measured.

6th. **DIP of HORIZON**, is the depression of the horizon of the sea, below the true horizon, by reason of the height of the observer's eye above the surface of the water.

7th. **AUGMENTATION** of the moon's semi-diameter, is a quantity to be added thereto, by reason of her growing nearer to the observer as she rises in altitude.

8th. **TRUE ALTITUDE** of the sun, moon, or star, is an arc of the azimuth circle, between the true horizon and the object's centre when corrected for dip of horizon, refraction, parallax, &c.

9th. **REFRACTION**, is a quantity always to be subtracted from the apparent altitude, by reason of the density of the atmosphere, which occasions it to appear higher than it really is,

10th. **PARAL-**

10th. **PARALLAX**, is a depression of the sun or moon below it's true place, by reason of the observer being on the surface of the earth above the plane, which passes through the centres of the earth and the object.

11th. **HORIZONTAL PARALLAX**, is the parallax of an object when at the horizon, which is the greatest that can happen; because the semi-diameter of the earth is perpendicular to the plane which passes through the centres of the earth and the object.

12th. **PARALLAX in ALTITUDE**, is a quantity arising from the horizontal parallax, which decreases as the object rises in altitude.

To find the APPARENT ALTITUDE of the SUN'S CENTRE, by an OBSERVATION taken at Sea.

N. B. You must allow for dip of horizon and the sun's semi-diameter, which you will find in tables for that purpose.

R U L E.

Should you observe the upper limb, subtract the sum of his semi-diameter and dip; but if his lower limb was observed, add the semi-diameter, and subtract the dip from the observed altitude.

E X A M P L E.

At sea the 1st of April, 1786, I observed the meridian altitude of the sun's upper limb to be $68^{\circ}.40'$. What was his apparent altitude when corrected?—the height of the eye being 18 feet above the surface.

Sun's

Sun's semi-diam.	16'.02"	Ob. alt. sun's UL.	68°.40'.00"
Dip of horizon	4 .03		— 20 .05
	20 .05	Anf. App. alt.	68 .19 .55

At sea the 1st of May, 1786, I observed the altitude of the sun's lower limb to be $54^{\circ}.30'.30''$: What was his apparent altitude when corrected?—The height of the eye being 21 feet above the surface.

$$\begin{aligned} \text{Obs. alt. sun's lower limb.} &= 54^{\circ}.30'.30'' \\ \text{Sun's semi-diameter} &= + 15 .54 \end{aligned}$$

$$\begin{aligned} &54 .46 .24 \\ \text{Dip of horizon} &— 4 .22 \end{aligned}$$

$$\text{Ans. App. lat. } 54 .42 .02$$

to find the TRUE ALTITUDE of the SUN'S CENTRE, by an OBSERVATION taken at Sea.

N.B. You must allow for dip of horizon, refraction, parallax in altitude and semi-diameter; all which you will find in tables for that purpose.

R U L E.

From the observed altitude subtract the refraction and parallax, then add the parallax in altitude and semi-diameter when the lower limb is observed; but if the upper limb is observed, subtract the refraction, dip of horizon and semi-diameter, and add the parallax in altitude.

E X A M-

E X A M P L E.

At sea the 1st of May, 1786, I observed the meridian altitude of the sun's lower limb to be $57^{\circ}.30'.30''$: What was his true altitude?—The eye being 21 feet above the surface.

Refraction	$0'.36''$	Paral. in alt.	$0'.05''$
Dip of hor.	$4'.22$	Semi-diam.	$15'.54$
	$4'.58$		$15'.59$

Observed alt.	$57^{\circ}.30'.30''$
	$- 04'.58$
	$57'.25.32$
	$+ 01'.15.59$

Ans. True alt. $57'.41.31$

At sea the 1st of April, 1786, I observed the meridian altitude of the sun's upper limb to be $68^{\circ}.40'$: What was his true altitude?—The height of the eye was 18 feet above the surface.

Refraction	$0'.22''$	Obs. alt. sun's U.L.	$68^{\circ}.40'.00$
Dip	$4'.03$		$- .20.27$
Semi-diam.	$16'.02$		
			$68'.19.31$
Sum	$20'.27$	Parallax in alt.	$+ 00'.03$

Ans. True alt. $68'.19.34$

88

1

Meridian
What
18 feet

40'	.00
20	.27

19.33
00.03

19-3

T

1

Subtract the dip of the horizon and refraction from the observed altitude, the remainder will be the true altitude required.

EXAM.

E X A M P L E.

At sea, I observed the altitude of the star Procyon to be $50^{\circ}.39'.40''$: What was its true altitude?—The height of the eye being 21 feet above the surface.

Dip of hor.	$4'.22''$	Procyon's obl. alt.	$50^{\circ}.39'.40''$
Refraction	0.47		5.00
Sum	<u>5.09</u>	Ans. True alt.	<u>$50^{\circ}.34'.38''$</u>

To find the APPARENT ALTITUDE of the MOON'S CENTRE, by an OBSERVATION taken at Sea.

R U L E.

To the observed altitude add the sum of her semi-diameter and augmentation, (when her lower limb is observed) and subtract the dip of horizon; but should her upper limb be observed, subtract the sum of her semi-diameter, augmentation, and dip of horizon, from the observed altitude; the remainder will be her apparent altitude.

In the English Channel at noon the 28th of May, 1781 I observed the altitude of the moon's lower limb to be $50^{\circ}.30'.20''$: What was her apparent altitude when corrected?—The height of the eye being 18 feet above the surface.

Moon

Moon's lower limb obs. alt.	50° .30' .20"
Semi-diameter	+ 16 .28
Augmentation	+ 12
Dip of horizon	50 .47 .00
	— 4 .03
Anf. App. alt.	50 .42 .57

At sea off Bourdeaux the 12th of May, 1786, at midnight, I observed the altitude of the moon's upper limb to be 37° .15' .30": What was her apparent altitude when corrected?—The eye being 30 feet above the surface.

Semi-diameter	14' .47"	Moon's up. limb obs.	37° .15' .30"
Augmentation	0 .10		— 20 .11
Dip of horizon	5 .14		
		Anf. App. alt.	36 .55 .19
Sum	20 .11		

To find the TRUE ALTITUDE of the MOON'S CENTRE,
by an OBSERVATION taken at Sea.

R U L E.

Find the apparent altitude, to which add the correction for reducing the apparent altitude of the moon to the true altitude, and it will give the true altitude required.

O

E X A M.

Moon

E X A M P L E.

At sea in the longitude of Greenwich, the 22d of March, 1786, at noon, the altitude of the moon's lower limb was observed to be $30^{\circ}.30'.20''$. What was her true altitude, the height of the eye being 18 feet above the surface?—Semi-diameter $15'.9''$, her parallax $55'.37''$.

For hor. par. $55'.37''$, alt. 30° f. tab. VIII. req. tab. $46'.31''$
 $55.37 \quad 31 \quad 46.6$

$2.6355 = \text{Prop. log. } 0.25$

$.6365 = \text{Prop. log. for } 41'.3''$

$9.5229 = \text{Constant log.}$

Moon's L.L. $30^{\circ}.30'.20''$

Semi-diam. $+ 15.9$

Augmentation $+ 8$

$2.7949 = \text{Pro. log. } 17'' \text{ nearly}$

Dip of hor. $30.45.37$

$— 4.03$

At alt. $30^{\circ} — 46'.31''$

Reduc. for correction $— 1$

App. alt. $30.41.34$

Correction $+ 46.14$

Correction 46.14

Anf. $31.27.48$ True altitude.

To find the APPARENT DISTANCE of the SUN and MOON'S CENTRES, when Corrected for SEMI-DIAMETER and MOON'S AUGMENTATION.

C A S E Ist.

When the nearest limbs are observed.

R U L E.

To the observed distance, add the sun and moon's true semi-diameters; their sum will be the apparent distance of the sun and moon's centres, as required.

E X A M P L E.

The 21st of April, 1786, at noon, I observed the distance of the sun and moon's nearest limbs to be $1^{\circ} 25' 40''$, when the altitude of the moon's lower limb was $42^{\circ} 13'$: What was the apparent distance of their centres?

The sun's true semi-diam.	15'.57"
The moon's semi-diam.	15.33
Augmentation	0.10

	Sum	31.40
Obs. dist. sun and moon's near. lim.		91.25.40

Anf. App. dist.	91.57.20
-----------------	----------

C A S E IId.

When the sun's farthest, and moon's nearest limbs are observed.

R U L E.

From their observed distance subtract the sun's true semi-diameter, and add the moon's; that sum will be the apparent distance of the sun and moon's centres, as required.

E X A M P L E.

The 1st of May, 1786, at noon, I observed the distance of the sun's farthest, and the moon's nearest limbs to be $44^{\circ}.30'.32''$, when the altitude of the moon's upper limb was $36^{\circ}.20'$: What was the apparent distance of their centres?

Moon's semi-diameter $16'.17''$

The moon's augmen. $+ 9$

————

Moon's true semi-diam. 16.26

————

Dist. of sun and moon's limbs $44^{\circ}.30'.32''$

Sun's true semi-diameter $0 15.54$

————

$44 14.38$

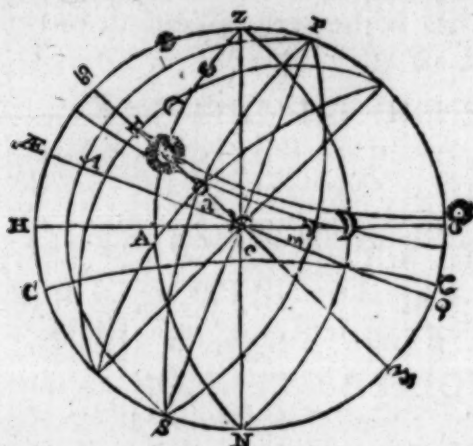
$+ 16.26$

————

Ans. The app. dist. of sun and moon's cent. $44 31.04$

————

On the Principal Angles and Arcs of Circles
RELATIVE TO NAVIGATION.



1st. **THE ALTITUDE** of the sun, moon, or star, is an arc of an azimuth circle, between its centre and the horizon, as $\odot A$ or $\star A$.

2d. **ZENITH DISTANCE** is the co. altitude, (viz.) the arc of an azimuth circle between the object's centre and the zenith, as $\odot Z$ or $\star Z$.

3d. **MERIDIAN ALTITUDE**, is when the object is on the meridian, and is at its greatest height for that day, as $\star H$ or $\odot H$.

4th. **AMPLITUDE** is an arc of the horizon, contained between the object's centre and the east at its rising, or the west at its setting. Thus $\odot \gamma$ is the moon's amplitude, and is equal to an angle made by the prime vertical, and an azimuth circle passing through its centre, as $\angle \gamma Z \odot$.

5th. **AZIMUTH** is an arc of the horizon, between the azimuth circle which passes through the centre of the object, and the north or south, as HA or OA , and is equal to an angle made at the zenith, as $\angle HZA$ or OZA .

6th. **RIGHT ASCENSION** is an arc of the equator, between the object's meridian, and the first point of the sign aries, as ϖa is the right ascension of the sun, and is equal to the $\angle aP\varpi$.

7th. **ASCENSIONAL DIFFERENCE**, is an arc of the equator between the next equinoctial point, and that part of the equator that is cut by the meridian, that rises or sets with the parallel of declination of the object's centre, and the first point of aries or libra; as ϖm of the moon, and equal to $\angle \varpi P\varpi$ equal to the times the object rises before or sets after six o'Clock.

8th. **OBLIQUE ASCENSION**, is the sum or difference of the right ascension and the ascensional difference; that is, if the latitude and declination are different ways, the sum of the right ascension and ascensional difference is the oblique ascension; and their difference is the oblique descension.—But should the latitude and declination be both north or both south, their difference is the oblique ascension, and their sum the oblique descension.—In other words, oblique ascension and oblique descension, is an arc of the equator between the first point of aries, and that part of the equator which rises or sets with the centre of the object, on the surface of the sphere.

9th. **LATITUDE** of a place, is an arc of the meridian between the equator and the place, as ÆZ .

10th. **LATITUDE** of the moon or star, is an arc of a circle of longitude between its centre and the ecliptic as $L\varnothing$.

11th. **DIFFERENCE** of latitude is an intercepted arc of the meridian between two parallels of latitude, which can never exceed 180 degrees; or it is the nearest distance between two parallels of latitude.

12th. **LONGITUDE** of the sun, moon or star, is an arc of the ecliptic between the first point of aries and a circle of longitude passing through the centre of the object, thus $\gamma \odot$ is the sun's longitude.

13th. **LONGITUDE** on the earth, is an arc of the equator reckoned between the meridian of any place, and the meridian where longitude takes its beginning.

14th. **DIFFERENCE** of long. on the earth, is an arc of the equator between the meridians of any two places, as Aa, and it equals the $\angle APa$.—*N. B.* from what has been said of latitude and longitude, in respect to the earth and heavens, it is evident they are very different, as latitude on the earth is an arc of the meridian, but in the heavens an arc of a circle of longitude; longitude on the earth is an arc of the equator, but in the heavens it is an arc of the ecliptic.

15th. **DECLINATION**, is an arc of the meridian between the equator and centre of the object, as a $\odot$, or $m \gamma$, and when it is on the north side of the equator, it is north declination, but on the south side, south declination.

16th. **SUN** or **MOON**'s place, is that sign, degree, minute, &c of the ecliptic, that the sun or moon is in at any time, as $\odot$.

17th. **TWILIGHT**, is that medium between light and darkness, before sun rise and after sun set.

18th. **CREPUSCULUM**, is a parallel circle to the horizon at 18 degrees below it, as C c C, at which twilight begins and ends.

19th,

19 THE HOUR of the day or night, is an arc of the equator counted between the meridian of the place, and another meridian passing through the centre of the sun at any time.

On finding the Sun's Declination.

C A S E Ist.

To find the declination for any particular hour, by the table of the sun's declination for the meridian of London.

R U L E.

If A.M. take the difference between the preceding noon and noon of the day.—If P.M. you must use the difference between the noon of the day and following day.

And say as 24 hours are to that difference, so are the hours and minutes elapsed since the last noon to a fourth number, which being added or subtracted to the degrees and minutes against the noon of the day or preceding noon, gives the declination as required.

N. B. If the declination be increasing, you add; but if decreasing, you subtract.

E X A M P L E.

Let it be required to find the sun's declination for the 15th of May, 1786, at 5 in the morning, and at 5 in the evening.

For

Ans. 7
in the m
was 19

(153)

For the morning.

14th May, dec.	18°.44'
15th Do.	18 .58
Difference	00 .14

As 24 hours .. 14' : . 17 hours .. 10' nearly.

14th May, dec.	18°.44'
Difference	00 .10
Morning's dec.	18 .54

For the Evening.

15th May	18 .58'
16th Do.	19 .12
	00 .14

As 24 hours .. 14' : : 5 hours .. 3' nearly.

15th May dec.	18°.58'
Difference	00 .03
Evening's dec.	19 .01

Anf. The sun's declination the 15th of May, 1786, at
in the morning, was 18°.54', and at 5 in the evening,
was 19°.01'

C A S E

C A S E IId.

To find the sun's dec. for any particular hour, by the table of sun's dec. to answer any meridian.

R U L E.

Divide the degrees of longitude by 15, and if you are in west longitude, the time it gives must be added to the time you want to find the dec. for, but if east longitude, subtracted; having then found the true time at London, proceed as directed in Case I.

E X A M P L E.

Let it be required to find the sun's declination for the 15th of Sept. 1785, at 7 in the morning, and at 7 in the evening, in latitude 45 degrees west?

$$\begin{array}{r} 15 \overline{)45(3} \\ \underline{45} \end{array}$$

Having divided the degrees of longitude by 15, I find the quotient 3 hours, to which I add 7 hours (it being west longitude) gives 10 hours the time at London; then I proceed with 10 hours as in case I.

For the Morning.

14th Sept. dec. $3^{\circ}.12'$
15th ditto 2 .48

Difference 0 .24

Ans. in longi
2^o.50',

N.B.
semi-dia
in any lo
in like m

As

As 24 hours .. 24' : : 22 hours .. 22'.

14th Sept. dec. $3^{\circ}.12'$
 Difference 22

Morning's dec. 2 .50

For the Evening.

15th Sept. dec. 2 .48
 16th ditto 2 .25

Difference 0 .23

As 24 hours .. 23' : : 10 hours .. 10' nearly.

15th Sep. dec. 2 .48
 Difference 0 .10

Evening's dec. 2 .38

Ans. The sun's declination the 15th of Sept. 1785, in longitude 45 degrees west, in the morning, was $2^{\circ}.50'$, and at 7 in the evening $2^{\circ}.38'$.

N.B. Should you want to know the sun or moon's semi-diameters, or moon's horizontal parallax at any hour in any longitude, it is done from the Nautical Almanack, in like manner as above.

MERIDIAN OBSERVATIONS.

ON FINDING the LATITUDE by an OBSERVATION at NOON.

N. B. In finding the latitude, you may count the sun's semi-diameter at all times 16 miles or minutes, which will be found true enough ; but in finding the longitude it is necessary to make use of the nautical almanac, for the sun and moon's true semi-diameters.

C A S E Ist.

When the sun or star has no declination.

R U L E.

The meridional zenith distance is equal to the latitude of the place, for then the zenith distance is the arc of the meridian intercepted between the equator and zenith if the object when on the meridian be south of you, the latitude is north, and the contrary.

E X A M P L E.

At sea, I observed the altitude of the sun's lower limb to be $48^{\circ}.10'$ south of me, when his declination was nothing, the height of the eye being 20 feet above the surface : What was the latitude ?

Dip for
Refract.

The d
declination

At sea
be in t

Decl

D

Dip for 20 feet = $4' . 16''$ Refraction = $0 . 51$

 $5 . 07$

Observed alt. = $48^{\circ} . 10$ Dip & refract. = $- 5$

 $48 . 5$ Sun's semi-diam. + 16

True altitude $48 . 21$ $90 . 00$

Zenith distance $41 . 39$ S.Declination $00 . 00$

Anf. Latitude $41 . 39$ N.

C A S E II d.

When the sun or star is in the zenith.

R U L E.

The declination is equal to the latitude; and if the declination be north, the lat. will be north, and contrary.

E X A M P L E.

At sea the 1st of January, 1786, I observed the sun to be in the zenith: What was the latitude?

Declination for Jan. 1st, 1786, is $22^{\circ} . 59'$ South.Anf. The latitude is $22^{\circ} . 59'$ S.

P

At

At sea on the 12th of June, 1786, the sun was in the zenith : What was the latitude ?

Declination for June 12, 1786, is $23^{\circ}.12'$ North.

Anf. The latitude was $23^{\circ}.12'$ N.

C A S E III.

When the sun or star has declination and zenith distance.

R U L E.

When they are both of one denomination, that is, if the object when on the meridian be to the northward of you, and its declination be north ; or to the southward and its declination be south, their difference will be the latitude of a contrary name, when the zenith distance is greater than the declination ; and if the zenith distance equal the declination, the latitude vanishes and the place is situated under the equator : But when the zenith distance is less than the declination, their difference is the latitude of the same name.

E X A M P L E.

At sea 1st of August, 1786, I observed the altitude of the sun's lower limb to be $50^{\circ}.30'$ north of me, the height of the eye being 20 feet above the surface : What was the latitude ?

Refraction

Refraction
Dip

At sea
ed to be
south, th
above th

Dip
Refraction
Semi-dia

Correct.

Refraction	0'.47"	Observed altitude	50°.30'
Dip	4 .16	Dip & refraction	— 5
	5 .03		50 .25
		Sun's semi-diam.	+ 16
			50 .41
		True altitude	90 .00
			39 .19 N.
		Zenith distance	17 .58 N.
		Declination	21 .21 S.
		Ans. Latitude	

At sea, the altitude of the sun's upper limb was observed to be 85°.20' south, when his declination was 23°.26' south, the height of the observer's eye being 22 feet above the surface : What was the latitude ?

Dip	4'.28"	Observed altitude	85°.20'
Refraction	0 .05	Correction	— .21
Semi-dia	16 .00		84 .59
	20 .33	True altitude	90 .00
Correct.			5 .01 S.
		Zenith distance	23 .26 S.
		Declination	18 .25 S.
		Ans. Latitude	

C A S E IVth.

When the meridian, zenith distance, and the declination of any object have contrary names.

R U L E.

The sum of the meridian zenith distance and declination, is the latitude of the place of the same name as the declination.

E X A M P L E.

At sea the 1st of August, 1786, I observed the altitude of the sun's lower limb on the meridian to be $61^{\circ}.48'$ south of me, when my eye was 24 feet above the surface: What was the latitude?

Dip $4^{\circ}.40''$	Observed altitude $61^{\circ}.48'$
Refraction 0.30	Dip and Refract. $- 5$
5.10	61.43
	Sun's semi-diam. $+ 16$
	True altitude 61.59 S.
	90.00
	Zenith distance 28.01 S.
	Declin. 17.58 N.
	Ans. Latitude 45.59 N.

N. B. In all latitudes greater than $66^{\circ}.30'$, the sun does not set for several days together, and many stars never set, but transit the meridian below the pole as well as above; in that case they may be observed upon the meridian twice in 24 hours.

C A S E Vth.

When the object is observed to be on the meridian
below the pole.

R U L E.

Add the complement of the declination to the true
meridian altitude, their sum will be the latitude of the
same name as the declination.

E X A M P L E.

At sea, I observed the altitude of the sun's lower limb
on the meridian below the pole to be $7^{\circ}.50'$, the decli-
nation being $22^{\circ}.30'$ N. and the height of my eye 24
feet above the surface: What was the latitude?

Dip	$4^{\circ}.40''$	Observed altitude	$7^{\circ}.50'$
Refraction	6.37	Dip and refraction	$- 11$
	11.17		
		Semi-diameter	7.39
			$+ 16$
		True altitude	7.55
Declin.	$90^{\circ}.00'$	Co. Declination	67.30
	22.30		
		Latitude	75.25
Co. Dec.	67.30		

Ans. The latitude is $75^{\circ}.25'$ N. it being N. declination.

DOUBLE ALTITUDES,

O R

OBSERVATIONS OFF THE MERIDIAN.

C A S E Ist.

To find the latitude by taking two altitudes either in the forenoon or afternoon, having the latitude by account and the intermediate time by a common watch.

R U L E S.

1st. To the arithmetical complement of the co. sine of the latitude by account, add the arithmetical complement of the co. sine of the sun's declination, and call the sum log. ratio.

2^d. Subtract the hours and minutes when each altitude was taken from each other, and half the remainder, and call it half elapsed time, with which enter the tables, and from the column of half elapsed time, take the logarithm answering thereto, and set it down under the log. ratio.

3^d. From the natural sine of the greater altitude, take the natural sine of the least, and find the log. of the difference, which set down under the log. ratio.

4th. Add these three logs. together, and with the sum enter the table of middle time, where having found the log. nearest thereto, take out the time corresponding

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3^d. A
exceed f

to it, and put it down under the half elapsed time; subtract the least from the greater, their difference will be the time from noon when the greatest altitude was taken.

5th. With this time enter the tables, and from the column of log. rising, take out the log. corresponding thereto, and from it subtract the log. ratio, the remainder will be a common log. which being found in any table of logs. and added to the natural sine of the greatest altitude, will give the natural sine of the meridian altitude of the sun, or its altitude at noon.

6th. Having the meridian altitude, the latitude of the place is found by the usual method, that is, by one of the preceding cases, according to which it may fall under.

N. B. Should the latitude found as above differ greatly from the latitude by account, it will be necessary to repeat the operation, using the latitude last found, instead of the latitude by account.

OBSERVATIONS on this METHOD of finding the LATITUDE.

1st. It holds good any time between the hours nine A.M. and three P.M.

2d. Altitudes taken so near together as 45 minutes, are liable to a small error, particularly between nine and ten o'clock; but between ten and eleven it will hold good, provided you take full 45 minutes between them.

3d. Altitudes taken one A.M. the other P.M. must not exceed five hours between them.

4th. The

4th. The space of time between the two observations should be longer than the second altitude from noon.

5th. Altitudes taken AM. and PM. if ten minutes elapse between the observations, it is sufficient, provided always in this case, that the space or portion of the diurnal arc comprehended between the highest altitude and the meridian, be not greater than that portion (or nearly so) which answers to the half elapsed time, between taking the two altitudes.

6th. In sailing to the eastward you must add to the elapsed time, at the rate of one minute of time for every 15 miles of longitude sailed, between the two observations, and subtract sailing to the westward.

7th. In sailing in any other direction, let the bearing of the sun be observed by the compass at the instant of the first observation, take the number of points between it and the ship's course, corrected for lee way, with which if less than 8 points, or of what it wants of 16 points, if more than 8, and the distance run between the observations, enter the traverse table, and take out the difference of latitude corresponding to them; add this difference of latitude to the first altitude if the number of points between the ship's course and the sun's bearing are less than 8, but subtract if they are more than 8, and the first altitude be reduced to what it would have been if observed at the same place where the second was.

Note, The result of this operation will be the latitude of the ship at the time when the second altitude was taken, and must be reduced to noon by means of the log.

At C
51° 29'
was obse
was 14°
Al. S's L
Dip
Ref

Se-di.

True

1. 1. "

2. 30. 20

0. 26 00

2. 4. 20

1. 2. 10

0. 28. 38

0. 33. 32

Nat.

Nat.

E X A M P L E Ift.

At Chelsea the 15th of December, 1786, latitude $51^{\circ}.29'$ N. at $10^h.26'$ the altitude of the sun's lower limb was observed to be $12^{\circ}.22'.49''$, and at $12^h.30'.20''$ it was $14^{\circ}.37'.15''$: What was the true latitude?

Al. S's LL. 1st ob.	$12^{\circ}.22'.49''$	Al. S's LL. 2d ob.	$14^{\circ}.37'.15''$
Dip.	— 0.00	Dip	— 0.00
Refraction	— 4.16	Refraction	— 3.31

	$12.18.33$		$14.33.44$
⊙ Se-di. & parr.	+ 16.27	⊙ Se-di. & Parr.	+ 16.27

⊙ True altitude	$12.35.00$	⊙ True altitude	$14.50.11$
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Lat. $51^{\circ}.29'.00''$	ar. co. of co. S.	$0,20569$
$2.30.20$ al.	$14.50.11$	$= 25606$
Dec. $23.19.08$	ditto	$0,03701$

0.26 oal.	$12.35.00$	$= 21786$	Log. ratio	$0,24270$
-------------	------------	-----------	------------	-----------

$2.4.20$ elap. time	3820	Common Logarithm	$3,58206$
---------------------	--------	------------------	-----------

$1.2.10$ Log. of $\frac{1}{2}$ the elapsed time	$0,57196$
---	-----------

$0.28.38$ Log. of the middle time	$4,39672$
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$0.33.32$ Time from noon.—Log. rising	$3,02878$
Log. ratio	$0,24270$

Common log.	611	$2,78608$
-------------	-------	-----------

Nat. fine of greater alt.	25606	
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		$90.00.00$
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Nat. fine of merid. alt.	26217	$15.11.56$
--------------------------	---------	------------

Merid. zenith dist.	$74.48.04$	N.
---------------------	------------	----

The sun's declination	$23.19.08$	S.
-----------------------	------------	----

True latitude	$51.28.56$	N.
---------------	------------	----

E X A M P L E. IIId.

The 20th of July, 1779, being at sea in latitude $39^{\circ}.28'$ N. by account, at $11^{\text{h}}.30'.15''$ by my watch, the altitude of the sun's lower limb was observed to be $68^{\circ}.18'.45''$; and at $12^{\text{h}}.26'.28''$, it was $70^{\circ}.58'$; the height of my eye above the surface of the sea being 2 feet: What was the true latitude of the ship?

Anf. The true latitude $39^{\circ}.28'$ N.

E X A M P L E IIIId.

Being at sea in latitude $13^{\circ} 44'$ N. the sun's declination was $19^{\circ}.48'$ S. at $12^{\text{h}}.12'$ by my watch, the altitude of sun's centre was observed to be $56^{\circ}.14'20''$, and at $3^{\text{h}}.20'$ it was $30^{\circ}.14'.15''$: What was the true latitude of the ship?

Anf. The true latitude $13^{\circ}.49'$ N.

N.B. When the altitudes are taken one before and one after noon, if it is convenient to observe the latter altitude when it is just equal to that taken before noon, the work will be much contracted.

E X A M P L E.

Being at sea in latitude $50^{\circ}.46'$ N. when the sun's declination was $14^{\circ}.55'$, at $9^{\text{h}}.7'.18''$ by my watch, the altitude of the sun's centre was observed to be $15^{\circ}.45'$, and at $2^{\text{h}}.25'.44''$, it was observed to have the same altitude: What was the true latitude of the ship?

Time

by W. Alt. $\odot$'s Natural

" center. sine.

7.18—15.45 27144 Lat. 50.46 ar.co.of co.s.o, 19895

25.44 Dec. 14.55 ditto 0,01489

18.26 Log. ratio 0,21384

39.13 Log. rising 4,36504

14166 Common log. 4,15120

41310 = merid. alt. $24^{\circ}.24'$

Zenith dist. 65 .36 S.

Declination 14 .55 N.

Anf. True lat. 50 .41 N.

In the preceding examples, it has been supposed that both altitudes were taken at the same place; but as that can seldom happen at sea, it is necessary to shew how to correct one of the altitudes, so as to make it what it would have been if observed at the same place where the other was; and this may readily be done, as follows:

Let the bearing of the sun be observed by the compass at the instant of the first observation; take the number of points between it and the ship's course, corrected for leeway, if she makes any; with which, if less than eight, subtract what it wants of sixteen points, if more than eight, and the distance run between the observations, enter

Time

enter the traverse table, and take out the difference of latitude corresponding to them. Add this difference of latitude to the first altitude, if the number of points between the sun's bearing and ship's course were less than eight; but subtract it from the first altitude, if the number of points were more than eight, and it will be reduced to what it would have been, if observed at the same place where the second was.

Note, The result of the operation will be the latitude of the ship at the time when the second altitude was taken and must be reduced to noon by means of the log.

E X A M P L E.

May 23d, 1786, lat. by account $39^{\circ}.20'$ N. the sun's declination $20^{\circ}.40'$, at $11^h.24'.35^s$, by watch, the apparent altitude of the sun's lower limb was $68^{\circ}.18'.50''$, the azimuth of his centre was S. 8° W. by compass, and at $12^h.20'.15''$ the apparent altitude of his lower limb was $70^{\circ}.58'$, the ship's course between the observations, was E $\frac{1}{2}$ N. 2 miles an hour, Dip $4'.20''$: What was the true latitude?

Sh. co. $95^{\circ}.37'$ Diff. lat. — $31''$ Alt. $\odot$ LL. $70^{\circ}.58'.00''$
 $\odot$ bear. 8 .00 Alt. $\odot$ LL. $68.18.50$ Dip — . 4 .20

<u>103 .37</u>	<u>68.18.19</u>	<u>70 .53 .40</u>	
180 .00	Dip. — 4.20	Ref. — .19	

<u>76 .22</u>	<u>68.13.59</u>	<u>70 .53 .21</u>	
	Ref. — 23	$\odot$'s S.D. + 15 .50	

	<u>68.13.36</u>	<u>tr.al. $\odot$ ce. 71 .09 .11</u>	
$\odot$'s S.D.	+ 15.50		

True alt. $\odot$'s centre 68.29.26

Ans. True latitude $39^{\circ}.15'$ N

July 10th, 1786, Lat. by account $49^{\circ}.24' N.$ $11^h.2'.20''$
 the app. altitude of the sun's L.L. was $60^{\circ}.00'$, the
 azimuth of his centre due south by compass, at $12^h.11'.10''$
 the app. altitude of his L.L. $62^{\circ}.09'$, the ship's course
 between the observations was E.S.E. $\frac{1}{2}$ E. at the rate of $6\frac{1}{2}$
 miles an hour, Dip $4'.30''$: What was the true latitude.

Anf. True latitude $49^{\circ}.22' N.$

To find the Error of the Watch from the DOUBLE ALTITUDES.

R U L E.

Write down the time from noon per watch, when the
 greatest altitude was taken, also the time corresponding
 to the log. rising, their difference will be the error of the
 watch, if they are both A.M. or both P.M. but if one
 is A.M. and the other P.M. their sum will be the error.
 In either case, if the time by the watch was earliest, the
 watch was too slow; but if latest, it was too fast.

In the preceding EXAMPLES.

Example 1st. Time for log. rising $0^h.33'.35''$ P.M.
 Time per watch $0.30.20$ P.M.

Anf. Watch too slow $0.3.15$

Example 2d. Time for log. rising $2^h.39'.13''$ P.M.
 Time per watch $2.25.44$ P.M.

Watch too slow 13.29

Q

Methods

Methods to regulate the going of a Watch.

Having the latitude and time of observation per watch, with the sun's true altitude and declination given.

R U L E.

Add together the co. latitude, zenith distance, and polar distance, from half that sum subtract the zenith distance, and note the remainder; then add together the arithmetical complements of the sines of the co. latitude and polar distance, and the log. sines of half the sum, and remainder; half the sum of these four logarithms is the co. sine of half the number of degrees and minutes, &c. or it is the cosine of half the horary angle or distance of the sun from noon, which being doubled, multiply it by 4, then the seconds will be thirds, the minutes seconds, and the degrees minutes of time.

E X A M P L E.

At Chelsea, in lat. $51^{\circ}.29'N$. December 15, 1786, in the forenoon, the following observations were made: Required the error of the watch?

Time per watch	$10^h.26'.00''$	Alt. sun's L.L.	$12^{\circ}.22'.49''$
		Refraction	$— 4.16$
Latitude	$51^{\circ}.29'N$.		$12.18.33$
	90.00	Semi.dia. & Paral.	$+ 16.27$
Co. lat.	38.31	☉ True altitude	$12.35.00$
Declin.	$23.18.56 S$.	Zenith dist.	$77.25.00$
	$90.00.00$		
Po. di.	$113.18.56$		Z.D.

Z.D. $77^{\circ}.25'.00''$ Co. Lat. $38^{\circ}.31'.00''$ —S. co. ar. 0,20569Polar Dist. $113^{\circ}.18'.56''$ —S. co. ar. 0,03700

 $2)229^{\circ}.14'.56''$

 $\frac{1}{2}$ Sum $114^{\circ}.37'.28''$ —S. 9,95859

 $77^{\circ}.25'.00''$

Remainder $37^{\circ}.12'.28''$ —S. 9,78154

 $2)19,98282$

 $11^{\circ}.21'.30'' = \text{Co. S. } 9,99141$

 2

 $22^{\circ}.43'.00''$

 4

 $1^{\circ}.30'.52''$

 $12^{\circ}.00'.00''$

True time $10^{\text{h}}.29^{\text{m}}.08^{\text{s}}$ A.M.Time per watch $10^{\text{h}}.26^{\text{m}}.00^{\text{s}}$ A.M.

Watch too slow — $3^{\text{m}}.08^{\text{s}}$

December 15th, 1786, at Chelsea; at $12^{\text{h}}.33^{\text{m}}.30^{\text{s}}$ per watch, the altitude of the sun's lower limb was $14^{\circ}.37'.15''$
 What was the error of the watch?

Anf. Watch too fast 2 seconds.

Q 2

In

In latitude $16^{\circ}.24'$ N. the sun's declination being $5^{\circ}.42'$ S. the altitude of the sun's lower limb was observed $47^{\circ}.12'$, the time per watch being $2^{\text{h}}.39'$ P.M. What was the error of the watch, the height of the eye being 15 feet above the surface?

Ans. The watch was too slow $9'.40''$.

ANOTHER METHOD.

R U L E.

1st. Write down the latitude, and against it, it's secant less radius.

2d. Under the latitude write the declination, and it's secant less radius.

3d. Add the secant's together, and call their sum ratio A.

4th. From the latitude and declination find the merid. altitude, and against it write it's natural sine.

5th. Under it write the sun's altitude at the time of observation, and it's natural sine.

6th. To the logarithm of the difference of the natural sines, add ratio A, their sum is the log. rising.

N.B. If

N.B. If in the forenoon the rising found by this method exceeds the time the observation wants of noon, their difference is the time the watch goes too fast, and the contrary. If in the afternoon, the rising found is greater than the time of observation, their difference is the time the watch goes too slow, and the contrary.

E X A M P L E.

At sea, in latitude $48^{\circ}.38'$ N. at 15 minutes past 11 o'clock, I observed the sun $63^{\circ}.06'$ high, the sun declination being $22^{\circ}.12'$ N. What was the error of my watch?

Lat. $48^{\circ}.38'$ Sec. 0,17988
Dec. 22 .12 Sec. 0,03345

Lat. N. $48^{\circ}.38'$
Dec. N. 22 :12

Ratio A. 0,21333

26 .26
90 .00

☉ meridian alt. 63 .34

Meridian alt. $63^{\circ}.34'$ N.S. 89545
11h. 15' Sun's alt. $63^{\circ}.06'$ N.S. 89180

2,56229 com. log. — 365
Ratio A: 0,21333

2,77562 Log. rising $0^h.25'.00''$
12 .00 .00

True time 11 .35 .00
Time per watch 11 .15 .00

Ans. Watch too slow — 20 .00

Q 3

Being

Being at sea in latitude $49^{\circ}.11'$ N. at $8^{\text{h}}.20'.20''$ A.M. I observed the altitude of the sun's lower limb $35^{\circ}.38'$, the height of my eye being 22 feet, and the declination $21^{\circ}.32'.11''$ N. What was the error of my watch,

Ans. Watch too fast $18'.56''$

At sea in latitude $18^{\circ}.20'.30''$ S. at $7^{\text{h}}.10'.16''$ A.M. the altitude of the sun's lower limb was observed $15^{\circ}.12'$, the declination was 10° N. What was the true time and error of the watch?

Ans. Watch too slow $10'.04''$.

On the VARIATION of the COMPASS.

DEFINITIONS and PRINCIPLES.

1st. It is an arc of the horizon contained between the meridian of the place and the magnetic meridian, and whenever the needle does not point directly to the north point of the heavens, that difference is called the variation of the compass, which is always east or west.

2d. The variation is found by an amplitude or azimuth.

3d. The sun's true amplitude is an arc of the horizon between the east or west points of the heavens, and the sun's centre at his rising or setting.

4th. Mag

4th. Magnetic amplitude is the number of degrees and minutes that the sun's centre is northward or southward of the east or west points at his rising or setting, as observed by the azimuth compass.

5th. The sun's true azimuth is an arc of the horizon contained between the meridian of the place, and the azimuth circle passing through its centre, and is equal to an angle made at the zenith, or it is the true distance the sun is from the true north and south points, at the time of observation.

6th. Magnetic azimuth is an arc of the horizon contained between the sun's azimuth and the meridian, as observed with the azimuth compass, or it is the apparent distance that an object is from the north and south points of the compass, at the time of observation.

7th. If the true and magnetic amplitudes or azimuths agree there is no variation, but should they differ, their difference is the variation of the compass.

To find the Variation of the Compass by an
AMPLITUDE.

R U L E.

As sine complement of the latitude is to radius, so is the sine of the object's declination, to the sine of the true amplitude.

CASE

C A S E Ist.

When the amplitudes have one name,

R U L E.

Their difference is the variation, and when north at sun rising if the magnetic exceeds the true, it is east, if south and the magnetic exceeds the true, it is west, at sun setting contrary: Or placing both the amplitudes before your face from you, if the true be to the right hand of the magnetic, the variation is east; but when it is to the left hand, the variation is west.

N.B. The eye is always supposed to be in the center of the horizon.

To Project the Figures Orthographically.

N. B. In these projections you use the line of chords only.

R U L E.

1st. Describe a circle of 60° and quarter it, place NS. and EW. always as per figure, and A. at the centre of the circle, then will N. represent the North, S. the South, E. the East, W. the West, and SAN. the horizon.

2d. Set

2d. Set off the latitude (if North) from N. to P. towards W. but if South from S. to I. towards W. and draw the axis PAI. or IAP. then at right angles to PAI. draw $\overline{EAQ}$. the equator.

3d. Set off the sun's declination on the primitive circle from the equator towards the North, if North declination, and towards the South when South declination, and draw the parallel of declination parallel to it, to cut the horizon SAN. in C. the place of the sun's rising or setting.

4th. Measure aE or aW on the line of chords, it is the sun's true amplitude North, if the declination be North, and South when the declination is South.

5th. Draw Ca parallel to WAE . towards the east when it is AM. but towards the West if PM. to cut the primitive in a .

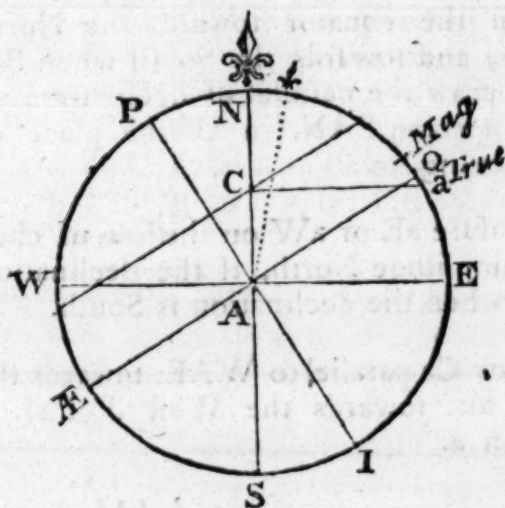
6th, Set off the mag. amp. if $\left\{ \begin{smallmatrix} \text{AM.} \\ \text{P M.} \end{smallmatrix} \right\}$ from $\left\{ \begin{smallmatrix} \text{E.} \\ \text{W.} \end{smallmatrix} \right\}$ towards N. when North, but towards S. when South.

7th, The distance between the mag. and true amplitudes set off from N. towards W. when West variation, and towards E. when East variation, will give the true North and the whole figure is finished. The distance from N. to true North measured on the scale of chords, is the variation of the compass.

E X A M-

E X A M P L E.

At sea, in lat. $30^{\circ}.00'$ N. the sun's declination being $23^{\circ}.20'$ N. the sun rose $36^{\circ}.30'$ to the northward of the east: What was the variation of the compass.



$$\begin{array}{rcl} \text{As co. S. lat. } 30^{\circ}.00' & = & 0.06247 \\ \text{Radius } 90.00 & = & 0.00000 \\ \text{Sine } \odot \text{ declin. } 23.20 & = & 9.59778 \end{array}$$

$$\begin{array}{rcl} \text{S. true amp. } E27.13N & = & 9.66025 \\ \text{Mag. amp. } E36.30N & & \end{array}$$

$$\text{Variation } \underline{\underline{9.17 \text{ E.}}}$$

Ans. The Variation was $9^{\circ}.17'$ East.

At sea in lat. $63^{\circ}.30'$ N. the sun's declination being $1^{\circ}.13'$ S. the sun rose $E37^{\circ}.30'$ S. What was the variation of the compass?

Anf. The Variation was $11^{\circ}.39'$ W.

Being at sea in lat. $20^{\circ}.00'$ S. sun's declination $19^{\circ}.00'$ the sun set 10° to the southward of the West. What was the variation.

Anf. $10^{\circ}.16'$ West.

At sea in lat. $50^{\circ}.00'$ S. sun's declination $20^{\circ}.00'$ N. the sun set West $19^{\circ}.00'$ North. What was the variation.

Anf. $13^{\circ}.09'$ East.

At sea the Lizard bore N.NE. distance 9 miles, when the sun's declination was $22^{\circ}.28'$ N. we observed the sun to rise East $17^{\circ}.46'$ North. What was the variation.

Anf. $18^{\circ}.33'$ West.

C A S E IId.

When the amplitudes have different names.

R U L E.

Their sum is the variation at sun rising-if the magnetic amplitude exceed the true; when North the variation is East, but when South it is West; at setting the contrary: placing both the amplitudes (before your face) from you, if the true be to the right-hand of the magnetic the variation is East, but when to the left hand the variation is West.

E X A M.

E X A M P L E.

At sea, in lat. $28^{\circ}.30'$ N. the sun's declination $11^{\circ}.1'$ South, the sun rose East $3^{\circ}.20'$ N. What was the variation.

Anf. Variation $16^{\circ}.07'$ East.

At sea, in latitude $40^{\circ}.00'$ S. sun's declination $4^{\circ}.4'$ north, the sun rose east $2^{\circ}.30'$ south: What was the variation?

Anf. Variation $8^{\circ}.40'$ west

At sea, in latitude $35^{\circ}.00'$ N. the sun's declination $10^{\circ}.00'$ S. the sun set W. by N. What was the variation?

Anf. Variation $23^{\circ}.29'$ west.

At sea, in latitude $50^{\circ}.00'$ N. the sun's declination $6^{\circ}.20'$ N. the sun set $2^{\circ}.00'$ to the southward of west: What was the variation?

Anf. Variation $11^{\circ}.55'$ east.

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W O R K A N A Z I M U T H.

Having the latitude of the place, sun's declination and altitude given ; his azimuth required ?

R U L E.

Add the complement of the latitude, the complement of the altitude, and the sun's distance from the pole, together ; from half that sum take the sun's distance from the pole, and note the remainder ; then add the arithmetical complement of the co. sine of the latitude, the arithmetical complement of the co. sine of the altitude, the sine of the half sum, and sine of the remainder together, the half sum thereof is the co. sine of half the azimuth ; double it, and reckon from the north in north latitude, and from the south when in south latitude.

N. B. When the latitude and declination have one name, subtract the declination from 90 degrees, the remainder is the sun's distance from the pole ; but when of different names, the sum of the declination and 90 degrees is the sun's distance from the pole.

S

E X A M.

(182)

E X A M P L E.

In the latitude of $48^{\circ}.56'$ N. sun's declination $20^{\circ}.16'$ N. his altitude in the afternoon was observed to be $38^{\circ}.30'$ What was his azimuth ?

☉ altitude	$90^{\circ}.00'$ <u>$38^{\circ}.30'$</u>	$90^{\circ}.00'$ <u>$20^{\circ}.16'$</u> declination
Co. alt.	<u>$51^{\circ}.30'$</u>	<u>$69^{\circ}.44'$</u> S's dist. from pole.

Lat. $90^{\circ}.00'$
 $48^{\circ}.56'$

Co. lat.	$41^{\circ}.04'$	Arith. co. log. sine	0,18248
Co. alt.	$51^{\circ}.30'$	Arith. co. log. sine	0,10646
☉ D. fr. pole	<u>$69^{\circ}.44'$</u>		

$\frac{1}{2}$) $162^{\circ}.18'$ sum

$\frac{1}{2}$ sum	$81^{\circ}.09'$	Sine $\frac{1}{2}$ sum	<u>9.99480</u>
☉ D. fr. pole	<u>$69^{\circ}.44'$</u>		
Remainder	<u>$11^{\circ}.25'$</u>	Sine	<u>9.29654</u>

$\frac{1}{2}$) $19,58028$

$51^{\circ}.55'$ co. sine 9.79014
2

True azim. N. $103^{\circ}.50'$ W.

Anf. Sun's true azimuth $103^{\circ}.50'$ from the N.

(183)

TO FIND THE
VARIATION of the COMPASS,
BY AN AZIMUTH.

Having the latitude of the place, the sun's declination, its altitude at the time of observation, with the magnetic azimuth given, the variation is found, thus:

R U L E.

Proceed to work the azimuth as before, comparing the azimuths in the morning, counting from the north; if the true exceeds the magnetic, their difference is the variation east, but if the magnetic exceeds the true, their difference is the variation west. In the afternoon the contrary, or placing the azimuths (before your face) if the true azimuth be to the right hand of the magnetic, the variation is east, but if to the left hand, the variation is west.

S 2

To

To project the Figures Orthographically.

N. B. Through the whole of these projections, you use only the line of chords.

R U L E S.

1st. Describe a circle, quarter it, lay off the latitude, draw the equinoctial axis, and parallel of declination, in all respects as directed in amplitudes.

2d. Set off the sun's altitude on the primitive circle from the horizon SAN, towards W, and draw the parallel of altitude parallel to SAN, to cut the parallel of the sun's declination in C, the place of the sun at that time.

3d. Draw Co parallel to WAE towards the east when it is AM, but towards the west if PM, till it meets an arc made (with FG half the length of the parallel of altitude) from the centre of the primitive circle, as A.

4th. From A through O, draw a line to cut the primitive circle, which place will be the true azimuth, it being measured on the line of chords to N when north latitude, or S when south latitude, sheweth the sun's true azimuth.

5th. Lay off the mag. azimuth if north latitude, from the north; but if south latitude from the south towards $\left\{ \begin{array}{l} E \\ W \end{array} \right\}$ when it is $\left\{ \begin{array}{l} \text{AM.} \\ \text{PM.} \end{array} \right\}$ to the mag. azimuth on the primitive circle.

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90⁰.00
27 .30 lat.

62 .30 co. lat.

77 .30 co. alt.

113 .01 sun's dist. from the pole

$\frac{1}{2}$)253 .01 sum

126 .30 $\frac{1}{2}$ sum

113 .01 sun's dist. from the pole

13 .29 remainder.

Co. fine lat. 27⁰.30' it's arith. co. 0,05207

Co. fine alt. 12 .30 it's arith. co. 0,01042

Sine $\frac{1}{2}$ sum 126 .30 9,90518

S. of remain. 13 .29 9,36766

$\frac{1}{2}$)19,33533

$\frac{0}{62.17}$ co. fine 9,66766
2

True azim. N. 124.34 Westerly.

Mag. azim. N. 111.10 Westerly.

Variation 13.24 West.

Ans. Variation 13⁰.24' West.

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Being at sea in latitude $37^{\circ}.10'$ south, when the sun's declination was $22^{\circ}.50'$ N. and his true altitude was $12^{\circ}.16'$, bearing by compass east $47^{\circ}.10'$ N. What was the variation of the compass?

Ans. Variation $5^{\circ}.38'$ east.

Being at sea, in latitude $47^{\circ}.39'$ N. when the sun's declination was $21^{\circ}.06'$ N. and his true altitude was $16^{\circ}.35'$, bearing by compass W. $2^{\circ}.02'$ S. What was the variation of the compass?

Ans. Variation $15^{\circ}.22'$ east.

Being at sea, in latitude $28^{\circ}.40'$ N. the sun's true altitude was $20^{\circ}.19'$, and declination $19^{\circ}.12'$ S. bearing by compass SW by W. What was the variation of the compass?

Ans. Variation $3^{\circ}.17'$ west.

At sea, Cape Finisler, whose lat. is $42^{\circ}.52'$ North bearing south $65^{\circ}.09'$ east distance 169 miles, we observed the sun to bear east 22° south, when his true altitude was $36^{\circ}.30'$, and declination $23^{\circ}.21'$ north: What was the variation of the compass?

Ans. $20^{\circ}.18'$ west.

Of

OF TIME and its DIVISION.

D E F I N I T I O N.

The day in astronomical accounts is supposed to begin at noon, or 12 hours later than the civil day of the same date, and is reckoned from 0 hours to 24 hours, or to the succeeding noon, when the next day begins, and tho' Navigators keep their log-book from noon to noon, or according to astronomical time. they date their observations according to civil time, the time before noon being called A.M. or ante meridian, and that afternoon P.M. or post meridian.

To find GREENWICH TIME in any Longitude.

R U L E S.

C A S E Ist.

When the longitude is west.

Add the longitude of the ship in time, to the ship's time, and the sum will be the time at Greenwich, of the same name as that at the ship.

N. B.

N. B. Should that time exceed 12 hours, reject 12 in the addition; and if the time at the ship be A.M. the Greenwich time will be P.M. of the same day; but if the ship's time be P.M. the Greenwich time will be A.M. on the following day.—To convert motion into time, multiply it by 4, the seconds will thirds, the minutes will be seconds, and the degrees will be minutes of time: And to turn time into motion, first reduce the hours and minutes into minutes, and divide by 4, the quotient of the minutes will be degrees, that of the seconds, minutes, and that of the thirds, seconds, &c.

E X A M P L E Ith.

At sea by observation August 13d, 1785, at 8h. 24'. 12" P.M. the longitude was found to be 63°. 27'. 30" W. Required the Greenwich time?

Given long. 63°. 27'. 30"	Ship's time 8h. 24'. 12"	
4	Long. in time 4 .13 .50	
Long. time 4h. 13'. 50" W.	Greenwich	} 0 .38 .02 A.M.
	T. Aug. 14.	

E X A M P L E IId,

At sea by observation August 6th, 1785. at 3h. 12'. 30" A.M. the longitude was 82°. 12'. 18" W. Required the time at Greenwich?

Given

Given long. $82^{\circ}.12'.18''$ W. Ship's T. $3^{\text{h}}.12'.30''$ A.M.

	<u>4</u>		<u>5 .28 .49</u>
Long. Time	$5^{\text{h}}.28'.49''$ W.		
	Greenwich T. Aug. 6th.	8 .41 .19 A.M.	

C A S E II.

When the longitude is east.

1st Subtract the longitude of the ship in time, from the ship's time; if subtraction cannot be made, borrow 12 in the hours. The remainder is the Greenwich time.

2d. If subtraction can be made, the Greenwich time will be A.M. or P.M. the same as the ship's time; but if it is necessary to borrow 12 in the subtraction, the Greenwich time will be of the contrary name to the ship's time. Also, if the ship's time was P.M. the Greenwich time will be on the same day; but if the ship's time was A.M. the Greenwich time will be P.M., on the day before.

E X A M P L E II.

At sea July 22d, in longitude $70^{\circ}.20'$ E. the time of the ship was $4^{\text{h}}.10'.12''$ A.M. What was the time at Greenwich?

Given long. $70^{\circ}.20'$ E. Ship's time $4^{\text{h}}.10'.12''$ A.M.

	<u>4</u>		<u>4 .41 .20 E.</u>
Long. in T.	$4^{\text{h}}.41'.20''$ E.		

Greenwich T. July 21st, 11 .28 .52 P.M.

E X A M P L E IIId.

At sea January 30th, at $11^{\text{h}}.12'.33''$ A.M. in longitude $9^{\circ}.16'.38''$ E. What was the Greenwich time?

Given long. $33^{\circ}.16'.38''$ E. Ship's T. $11^{\text{h}}.12'.33''$ A.M.

$\begin{array}{r} 4 \\ \hline \end{array}$	Long. in T. $2 \ .13 \ .07$ E.
Long. in T. $2^{\text{h}}.13'.07''$ E.	$\hline$

Greenwich time Jan. 30th, $8 \ .59 \ .26$ A.M.

$$\hline$$

E X A M P L E IIIId.

At sea September 14th, at $5^{\text{h}}.38'.40''$ P.M. the long. $78^{\circ}.42'.16''$ E. What was the Greenwich time?

Given long. $78^{\circ}.42'.16''$ E. Ship's T. $5^{\text{h}}.38'.40''$ P.M.

$\begin{array}{r} 4 \\ \hline \end{array}$	Long. in T. $5 \ .14 \ .49$ E.
Long. in T. $5^{\text{h}}.14'.49''$ E.	$\hline$

Greenwich time Sept. 14th, $0 \ .23 \ .51$ P.M.

$$\hline$$

A TABLE,

A TABLE with Rules and Examples, for finding the Moon's Semi-diameter and Horizontal Parallax, for any intermediate time not given in the Ephemerides.

Diff. in 12 hour.	Proportional part for intermediate hours.										
	1	2	3	4	5	6	7	8	9	10	11
1	0	0	0	0	0	1	1	1	1	1	1
2	0	0	1	1	1	1	1	1	2	2	2
3	0	1	1	1	1	2	2	2	2	3	3
4	0	1	1	1	2	2	2	3	3	3	4
5	0	1	1	2	2	3	3	3	4	4	5
6	1	1	2	2	3	3	4	4	5	5	6
7	1	1	2	2	3	4	4	5	5	6	7
8	1	1	2	3	3	4	5	5	6	7	7
9	1	2	2	3	4	5	5	6	7	8	8
10	1	2	3	3	4	5	6	7	8	8	9
11	1	2	3	4	5	6	6	7	8	9	10
12	1	2	3	4	5	6	7	8	9	10	11
13	1	2	3	4	5	7	8	9	10	11	12
14	1	2	4	5	6	7	8	9	11	12	13
15	1	3	4	5	6	8	9	10	11	13	14
16	1	3	4	5	7	8	9	11	12	13	15
17	1	3	4	6	7	9	10	11	13	14	16
18	2	3	5	6	8	9	11	12	14	15	17
19	2	3	5	6	8	10	11	13	14	16	17
20	2	3	5	7	8	10	12	13	15	17	18
21	2	4	5	7	9	11	12	14	16	18	19
22	2	4	6	7	9	11	13	15	17	18	20
23	2	4	6	8	10	12	13	15	17	19	21
24	2	4	6	8	10	12	14	16	18	20	22
25	2	4	6	8	10	13	15	17	19	21	23
26	2	4	7	9	11	13	15	17	20	22	24
27	2	5	7	9	11	14	16	18	20	23	25
28	2	5	7	9	12	14	16	19	21	23	26
29	2	5	7	10	12	15	17	19	22	24	27
30	3	5	8	10	12	15	18	20	23	25	27

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To find the Moon's Horizontal Parallax and Semi-diameter, for any given time.

R U L E Ist.

If the given time is either at noon or midnight, look in the nautical ephemeris for that day, and against it, in their proper columns, are the horizontal parallax and semi-diameter required.

E X A M P L E.

What was the moon's horizontal parallax and semi-diameter, November the 8th, 1785, at noon?

In page 127 of the ephemeris against the 8th day, I find the semi-diameter in the column for noon $15'.42''$, and the horizontal paral. in the column for noon $57'.36''$.

R U L E IId.

If the given time is between noon and midnight, that is in the afternoon of the given day.

1st. Look to the given day in the ephemeris, and take out the semi-diameter and horizontal parallax for both noon and midnight, and write them one under the other, and subtract them.

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2d. With

2d. With the differences enter the small table in the first column under difference for 12 hours, and against it under the hours after noon take out the seconds; if the semi-diameter was increasing from noon to midnight, it must be added to the semi-diameter for noon; but if was decreasing from noon to midnight, it must be subtracted from the semi-diameter for noon; the sum or difference, will be the semi-diameter required. Also, the difference of the horizontal parallax used in the same manner, and added to or subtracted from the horizontal par. for noon, the sum or difference, will be the horizontal par. requi.

E X A M P L E.

What was the moon's semi-diameter and horizontal parallax, July 14th, 1785, at 4 hours after noon?

	Semi-diam.	Hor. Par.
In the ephemerides July 14th, noon	14'.53"	54'.38"
Midnight	14.56	54.49
Difference	3	11
From the small table for 4 hours	1	4
S. dia. & hor. par. for noon increas. add	14.53	54.38
S. dia. & hor. par. at 4 hours afternoon	14.54	54.42

R U L E IIIId.

If the given time is between midnight and noon, or in the forenoon of the given day.

1st. Look into the ephemerides for the day next before the given day, and take out the semi-diameter and horizontal parallax for midnight; also for the given day take

take out the semi-diameter and horizontal parallax for noon, and write them under the other and subtract. Proceed with the differences to take out the quantities from the small table, as in rule 2d, but with the given time past midnight, and add to the semi-diameter, or subtract from the semi-diameter and horizontal parallax for midnight, according as they are increasing or decreasing, and the sums or differences will be the semi-diameter and horizontal parallax for the hour in the forenoon required.

E X A M P L E.

What was the moon's semi-diameter and horizontal parallax the 12th of September, 1785, at 19 hours after-noon, or 13th of September, at 7 hours in the forenoon?

	Semi-diam.	Hor. Par.
September 12th, midnight	15'.39"	57'.26"
13th, noon	15.47	57.54
Difference	8	28

From the table for 7 hours	5	16
S. dia. & hor. par. for mid. increas. add	15.39	57.26
Gives them for 7 hours after midnight	15.44	57.42

N. B. - If the given time is in hours and minutes, take the hour more or less than the given time which is nearest thereto, and proceed therewith as in the above example.—Thus if the time is 6^h.22", say 6 hours; but if it was 6^h.35", call it 7 hours.

PREPERATION FOR
WORKING the LONGITUDE,
By the AUTHOR's Method.

P R O B L E M Ist.

To find the correction of the moon's apparent altitude.

R U L E.

From the proportional logarithm of the moon's horizontal parallax, its index being increased by 10, subtract the log. sine of the moon's zenith distance, and the remainder will be the proportional log. of her parallax in altitude, from which subtract the moon's refraction; their difference will be the correction of the moon's apparent altitude as required.

E X A M P L E Ist.

Suppose the moon's apparent altitude to be $14^{\circ}.18'.42''$, the horizontal parallax $59'.20''$: What is the correction of her altitude?

Horizontal par.	$0^{\circ}.59'.20''$	P.L.	10,4820
Moon's Z. D.	$75.41.18$	Log.S.	9,9863

Parallax in alt.	$0.57.29$	P. log.	0,4957
Refraction	$— . 3.40$		

$0.53.49$	Correction required.
-----------	----------------------

E X A M.

E X A M P L E IIId.

Admit the apparent alt. of the moon was $50^{\circ}.35'.47''$, and her horizontal parallax $56'.44''$: What is the correction of her altitude?

Horizontal par. $56'.44''$ P. Log. 10,5014
 D Z. Dist. 39.24.13 Log. S. 9,8026

Parallax in alt. 36.01 P. Log. 0,6988
 Refraction — 0.47

35.14 Correction required.

E X A M P L E IIIId.

Admit the moon's apparent altitude to be $9^{\circ}.38'.00''$, and her horizontal parallax $54'.55''$: What is the correction of her altitude?

D's Horizontal parallax $0^{\circ}.54'.55''$ L. P. 10,5155
 D's Z. Distance 80.22.00 Log. S. 9,9938

D's Parallax in alt. 54.09 P. Log. 0,5217
 Refraction — 5.26

48.43 Correction required.

E X A M P L E IVth.

Suppose the moon's apparent altitude $27^{\circ}.20'.50''$, and the horizontal parallax $56'.26''$: Required the correction of her altitude?

Horizontal parallax	$0^{\circ}.56'.26''$	P. L.	10,5037
D's Z. Distance	62 .39 .10	Log. S.	9,9485
D's Parallax in alt.	50 .08	P. Log.	0,5552
Refraction	— 1 .50		
	<u>48 .18</u>	Correction required.	

P R O B L E M Ild.

To find a reserved logarithm, which call A.

R U L E.

Take the log. secant of the moon's apparent altitude, the log. co. sine of her true altitude, the log. secant of the sun or star's apparent altitude, and the log. co. sine of the sun or star's true altitude; the sum of these four logarithms rejecting 30 in the index, will be the reserved logarithm required.

E X A M P L E Ist.

Admit the moon's apparent altitude to be $14^{\circ}.18'.42''$, and the correction of her altitude found by problem 1st, $53'.49''$, also the apparent altitude of the sun $30^{\circ}.35'.58''$, and his refraction $1'.36''$: Required the log. A?

app.

☽'s app. alt.	$14^{\circ}.18'.42''$	Log. sec.	10,01369
Correction	$+ 53.49$		
☽'s true alt.	$15.12.31$	Log. co. f.	9,98452
☉'s app. alt.	$30.35.58$	Log. sec.	10,06513
Refraction	$- 1.36$		
☉'s true alt.	$30.34.22$	Log. co. f.	9,93499
			$9,99833 \log.A$

E X A M P L E. IId.

Suppose the apparent altitude of the moon was $50^{\circ}.35'.47''$, and the correction of her altitude found by problem 1st, to be $35'.14''$, also the apparent altitude of the sun $13^{\circ}.31'.09''$, and his refraction $3'.54''$: Required the logarithm A ?

☽'s app. alt.	$50^{\circ}.35'.47''$	Log. sec.	10,19738
Correction	$+ 35.14$		
☽'s true alt.	$51.11.01$	Log. co. f.	9,79715
☉'s app alt.	$13.31.09$	Log. sec.	10,01220
Refraction	$- 3.54$		
☉'s true alt.	$13.27.15$	Log. co. f.	9,98791
			$9,99464 \log.A$

E X A M-

E X A M P L E III^d.

Admit the apparent altitude of the moon to be $9^{\circ}.38'.00''$, and the correction of her altitude found by problem 1st, to be $48'.43''$, also the apparent altitude of the star Spica $11^{\circ}.17'$, its refraction being $4'.40''$: Required the logarithm A?

☾'s app. alt.	$9^{\circ}.38'.00''$	Log. sec.	10,00617
Correction	$+ 48'.43$		
☾'s true alt.	$10.26.43$	Log. co. f.	9,99274
*' app. alt.	$11.17.00$	Log. sec.	10,00848
Refraction	$- 4.40$		
*'s true alt.	$11.12.20$	Log. co. f.	9,99166
			<u>9,99905</u> log.A

E X A M P L E IVth.

Suppose the apparent altitude of the moon to be $27^{\circ}.20'.50''$, and the correction of her altitude found by problem first, $48'.18''$, also the apparent altitude of the star Spica to be $59^{\circ}.16'.20''$, its refraction being $34''$: Required the logarithm A?

☾'s app. alt.	$27^{\circ}.20'.50''$	Log. sec.	10,05147
Correction	$+ 48'.18$		
☾'s true alt.	$28.09.08$	Log. co. f.	9,94532
*'s app. alt	$59.16.20$	Log. sec.	10,29161
Refraction	$- 34$		
*'s true alt.	$59.15.46$	Log. co. f.	9,70851
			<u>9,99691</u> log.A

O N

WORKING the LONGITUDE,

By the AUTHOR's Method.

R U L E S.

1st. Find the moon's horizontal parallax, also the correction of the moon's apparent altitude, and the logarithm A, as directed in the preparatory work, problem first and problem second.

2d. Find the apparent distance of the sun and moon, or moon and star, also their apparent altitudes.

3d. To the correction of the moon's apparent altitude, add the refraction of the sun or star, the sum of which will be the correction of the difference of the apparent altitudes.

4th. If the altitude of the sun, or star, be greater than that of the moon, take the above correction from the difference of the apparent altitudes, but let them be added together if the moon's altitude be greatest, and you will have the difference of their true altitudes.

5th. To

5th. To the apparent distance add the difference of the apparent altitudes ; also take their difference.

6th. Take the log. sine of half the sum, the log. sine of half their difference, the constant log. 7,30103, and the logarithm A, add these four logs together, and their sum, rejecting 30 in the index, will be the common log. of a natural number.

7th. To this natural number add the complement arithmetical of the natural co. sine of the difference of the true altitudes, taken to 7 places of figures, and if the true distance is less than 90° , take the co. arithmetical of this sum, which will be the natural co. sine of the true distance.—But if the true distance be more than 90° , omit the 1 from the left hand of the sum, and the remaining figures will be the natural sine of an arc to which add 90° , and it will give the true distance which being obtained, the longitude will be found as follows.

8th. In the ephemerides amongst the distances of the sun or stars from the moon for the day of observation look for this true distance, and if it be there, the Greenwich time of observation will be found at the top of the column ; but should the true distance fall between two, which generally is the case, write under each other the two nearest, and subtract ; also take the difference of the first distance, and the true distance.

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9th. From the proportional log. of the second remainder, subtract the proportional log. of the first remainder, their difference will be the proportional log. of the time elapsed, since the time corresponding to the first distance taken from the ephemerides, which added thereto, is the true time of observation at Greenwich.

10th. The difference between the time at Greenwich and the time at the ship turned into longitude, gives the ship's true longitude from Greenwich, either east or west. If the time at the ship be greater than that at Greenwich, the longitude is east; if less, west.

EXAM-

E X A M P L E Iſ.

At ſea the 3d of April, 1782, in longitude per account $81^{\circ}.20'$ W. at $8h.9'.15''$ AM. per watch well regulated to apparent time, I obſerved the diſtance of the ſun and moon's neareſt limbs to be $108^{\circ}.0'.14''$, when the altitude of the moon's upper limb was $14^{\circ}.40'$, and the ſun's altitude $30^{\circ}.25'$ per lower limb, the height of the eye being 28 feet above the ſurface: What was the true longitude?

$81^{\circ}.20'$

4

D's Horizontal Parallax $59'.20''$
 Correction D's app. alt. $53'.49''$
 ☉'s Refraction 1.36

55.25

Long. in time 5.25.20 W.
 Ship's time 8.09.15 A.M.

Greenwich time 1.34.35 P.M. nearly

Logarithm A. 9.99833

☉ & D's obf. diſt.

$108^{\circ}.00'.14''$

+ 16.14 D's ſe. dia. & aug.

D's obf. alt.

$14^{\circ}.40'.00''$

— 16.14

Sun's ſemi-dia. + 16.02

$14.23.46$

☉ & D's app. diſt. $108.32.30$

Dip.

— 5.04

D's app. alt.

$14.18.42$

☉'s app. alt.

$30.35.58$

$108^{\circ}.32'.30''$

$16.17.16$ Diff. of app. altitudes

Sum

$124.40.56$

D's app. alt.

$14.18.42$

☉'s app. alt.

$30.35.58$

$\odot$ & $\odot$'s app. alt. 100° 32' 30" $\odot$'s app. alt. 14° 18' 42" $\odot$'s app. alt. 30° 35' 58"

(205)

108° 32' 30"	Diff. of app. altitudes	30° 35' 58"
16 .17 .16		14 .18 .42
Sum 124 .49 .46	$\frac{1}{2}$ { 62° 24' 53" S. 9,94759	16 .17 .16
Diff. 92 .15 .14	46 . 7 .37 S. 9,85785	— 55 .25
	Constant Log. 7,30103	Diff. of true alt. 15 .21 51
	Logarithm A, 9,99833	
	Com. Log. 7,10480 = Nat. Num. 12729100	
		0357380 co. ar N co. S

N. S. $17^{\circ} 58' 41'' = 3086480$
 $17^{\circ} 58' 41'' + 90^{\circ} = 107^{\circ} 58' 41'' = \text{true distance.}$

At 12 o'clock first distance $108^{\circ} 49' 24'' - 108^{\circ} 49' 24''$
 At 3 o'clock second dist. $107^{\circ} 11' 04'' - 107^{\circ} 58' 41''$

1 .38 .20 — 0 .50 .43
P. log. 0,5501
— P. log. 0,2626
1h.32'51" — P. log. 0,2875
12

13 .32 .51 = Greenwich time
8 . 9 .15 = Time at ship
4)5 .23 .36

80 .54 W. = true longitude.

U

E X A M P L E II.

At sea the 2d of June, 1782, longitude per account 77° E. at $8^{\text{h}}.35'.46''$ AM. per watch well regulated to apparent time, the distance of the sun and moon's nearest limbs was $86^{\circ}.39'.40''$, when the moon's altitude per lower limb was $50^{\circ}.25'$, and the sun's altitude per lower limb was $13^{\circ}.20'$, the height of the eye above the surface being 24 feet: What was the true longitude?

(206)

77° E.	
4	
5 .08	Long. in time E.
8 .35 .46	A.M. Ship's time
3 .27 .46	Greenwich T. per acco.

Horizontal parallax	$56'.44''$
Cor. of D's app. alt. $35'.14''$	
☉'s refract on 3 .57	
Logarithm A 9,99464	39 .11 Correction

☉ & D's obs. dist.	D's obs. alt.
$86^{\circ}.39'.40''$	$13^{\circ}.20'.00''$
D's f. di. & augm. + 15 .39	☉'s semi-dia. + 15 .49
☉'s semi-diam. + 15 .49	13 .35 .49
☉ & D's app. dist. 87 .11 .08	Dip. — 4 .40
	D's app. alt. $50^{\circ}.35'.59''$
	☉'s app. alt. 13 .31 .09

$87^{\circ}.11'.08''$	$50^{\circ}.35'.59''$
37 .04 .50	13 .31 .09
	27 .04 .50
	D. of app. alt. $27^{\circ}.04'.50''$

© & D's app. dif. 87°.11'.08"

Dip. — 4°.40' — 1°
D's app. alt. 50°.35'.59" ©'s app. alt. 13°.31'.09"

87°.11'.08"
37°.04'.50"

Sum $\frac{124.15.58}{50.06.18} \left\{ \begin{array}{l} 62^{\circ} 7' 59'' \\ 25.3.9 \end{array} \right\} \frac{1}{2}$ D. of app. alt. 37°.04'.50"
Diff. $\frac{50.06.18}{50.06.18}$ S. 9,94647 Cor. + 39.11
S. 9,62681 D. true alt. 37°.44'.01

At 3 o'clock 87°.15'.48"—87°.15'.48"
Con. log. 7,30103 Log. A. 9,99464

At 6 o'clock 85°.49'.29"—87°.3.23
Com. log. 6,86895 N. num. 7395150
1.26.19 0.12.25=P.L.1,1613
P.L.0,3192
2091300 co. ar. N. co. S.
9486450

0,8421=P.L. oh 25' 53" 051355=N co S 87° 3' 23" =
3 0 0

Greenwich true time — 3 25 53
Ship's time — 8 35 46

4) 5.9.53

77°.28'.15 E. true long.

E X A M P L E III^d.

At sea the 29th of April, 1784, in longitude per account 46° W. at 9^h. PM. apparent time, the distance of the moon's nearest limb from the star Spica was observed $43^{\circ}.20'.41''$, the altitude of the moon's lower limb was $9^{\circ}.26'.48''$, and that of the star $11^{\circ}.29'.49''$, the height of the eye being 16 feet: What was the true longitude?

Ans. The true longitude was $46^{\circ}.34'.15''$ W.

E X A M P L E IVth.

January 16th, 1786, in latitude $31^{\circ}.10'$ S. longitude per account $81^{\circ}.20'$ E. at 4^h. 14' AM. per watch well regulated to apparent time, the distance of the moon's farthest limb from Spica was observed to be $68^{\circ}.37'$, the altitude of the moon's lowest limb being $27^{\circ}.10'$, and that of the star $59^{\circ}.21'$, the height of the eye being 24 feet: Required the true longitude?

Ans. The true longitude was $82^{\circ}.19'$ E.

ON RECTIFYING COURSES.

C A S E Ist.

The COURSE Steered by the COMPASS and VARIATION given, the CORRECT or TRUE COURSE required.

N. B. You must suppose yourself placed in the centre of the compass, and looking from thence towards the different points thereon.

R U L E.

If the
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Ans.

R U L E.

If the variation is east, count the variation to the right-hand of the course steered by the compass; but if west, to the left-hand; it will give the true course required.

E X A M P L E S.

If I steer SWbyW. by the compass, when the variation is one point west: What's the true course?

Variation, 1 point towards the left-hand, (it being W. variation) from SWbyW. makes it SW. the true course.

Anf. SW.

Course by the compass SWbyW. variation 1 point east: What's the true course?

Variation 1 point towards the right-hand, it being east variation) from SWbyW. makes it WSW, the correct course.

Anf. WSW.

Course by the compass EbyS $\frac{1}{2}$ E, variation 1 $\frac{1}{2}$ point west: What's the true course?

Anf. EbyN.

Course by the compass NW $\frac{1}{4}$ W. variation 1 $\frac{1}{4}$ west: What's the correct course?

Anf. WNW.

Course by the compass NW $\frac{1}{4}$ W. variation 1 $\frac{1}{4}$ east: What's the true course?

Anf. NNW $\frac{1}{4}$ W.

Course by compass due N. variation $27^{\circ}.30'$ west:
What's the true course?

Ans. NNW $\frac{1}{2}$ W. nearly.

Course by the compass E. $8^{\circ}.27'$ N. variation $5^{\circ}.22'$
east: What's the true course?

Ans. E. $3^{\circ}.5'$ N.

Course by the compass SSE $\frac{1}{4}$ E. variation $17^{\circ}.25'$ west:
What's the correct course?

Ans. SE by S $\frac{1}{4}$ E. $33'$ east.

C A S E IId.

THE COURSE Steered by the COMPASS, LEE-WAY and
VARIATION given, the CORRECT COURSE required.

R U L E.

When the lee-way and variation are both one way,
that is both to the right-hand or left, their sum corrected
by case 1st. is the true course required. But when con-
trary ways, their difference is to be corrected the same
way the greater was to be allowed for.

E X A M P L E S.

Course by compass ENE. wind at north, lee-way $1\frac{1}{4}$
point, variation $1\frac{1}{4}$ east: What's the true course?

Lee-way $1\frac{1}{4}$ right-hand } Ans. E by S.
Variation $1\frac{1}{4}$ do.

3 Points towards the right-hand from ENE.
— makes it E by S. the correct course

Course

Course by compass NW. wind at NNE, lee-way $1\frac{1}{2}$ point, variation $1\frac{1}{2}$ west: What's the true course?

Lee-way $1\frac{1}{2}$ point left-hand } Anf. WbyN.
Variation $1\frac{1}{2}$ do.

—
3 Points towards the left-hand from NW.
— makes it WbyN. the true course.

Course by compass SSW. wind SE. lee-way $1\frac{1}{4}$ point, variation $\frac{3}{4}$ west: What's the true course?

Lee-way $1\frac{1}{4}$ point right-hand } Anf. SSW $\frac{1}{2}$ W.
Variation $\frac{3}{4}$ left do.

—
 $\frac{1}{2}$ Point towards the right hand (it being the greater) from SSW. makes it SSW $\frac{1}{2}$ W. the true course.

Course by compass SE. wind SSW. lee-way $\frac{1}{2}$ point, variation $1\frac{1}{4}$ east: What's the true course?

Variation $1\frac{1}{4}$ point right-hand
Lee way $\frac{1}{2}$ left-hand } Anf. SEbyS $\frac{1}{4}$ S.
—
Variation $1\frac{1}{4}$ right-hand

Course by compass NE. wind ESE. lee-way $5\frac{1}{2}$ variation 2 points west: What's the true course?

Lee-way $5\frac{1}{2}$ points left-hand
Variation 2 do. } Anf. NWbyN $\frac{1}{2}$ W.
—
Var. & lee-way $7\frac{1}{2}$ left-hand

Course by compass SE $\frac{1}{2}$ E. wind NEbyE $\frac{1}{2}$ E. lee-way 4 points, variation $1\frac{1}{2}$ west. What's the true course?

Lee-way 4 points right-hand
Variation $1\frac{1}{2}$ left-hand } Anf. SSE.
—
Lee-way $2\frac{1}{2}$ right-hand
—

CASE

C A S E IIIA.

The TRUE COURSE from PLACE to PLACE, and the VARIATION given; the COURSE to STEER by the COMPASS required?

R U L E.

If the variation is east, count the variation to the left-hand of the true course, and you have the course by the compass to steer; but if west, variation to the right-hand of the true course.

E X A M P L E.

True course from place to place, SW. variation 1 point west. What is the course by the compass?

Variation 1 point towards the right hand, from SW. makes SW by W. } Anf. SW by W.
the course to steer by compass

True course from place to place WSW. variation 1 point east. What is the course by the compass?

Variation 1 point towards the left-hand, from WSW. makes SW by W. } Anf. SW by W.
the course to steer by compass.

True course from place to place, NE $\frac{1}{2}$ E. variation $\frac{1}{2}$ point west: What's the course by the compass?

Anf. NE by E.

True course from place to place, NE $\frac{1}{2}$ N. variation $\frac{1}{2}$ point west. What is the course by the compass?

Anf. NE.

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True course from place to place, E by N. variation $1\frac{1}{2}$ point east. What is the course by the compass?

Ans. E. N E. $\frac{1}{2}$ N.

True course from place to place NNW $\frac{1}{2}$ W. variation $1\frac{1}{2}$ point east. What is the course by the compass?

Ans. NW.

True course from place to place, WNW. variation $1\frac{1}{2}$ west. What is the course by the compass?

Ans. NW $\frac{1}{4}$ W.

True course from place to place, NNE $\frac{1}{2}$ E. $37^{\circ} \frac{1}{2}$ N. variation $27^{\circ} 30'$ east. What is the course by the compass?

Ans. N.

True course from place to place, E. $3^{\circ} 5'$ N. variation $5^{\circ} 21'$ east. What is the course by the compass?

Ans. E. $8^{\circ} 26'$ N.

True course from place to place, SE by S $\frac{1}{4}$ E. variation $17^{\circ} 25'$ west. What is the course by the compass?

Ans. SSE $\frac{1}{4}$ E. nearly.

The GENERAL AVERAGE for ALLOWANCE of LEE-WAY.

- 1 Close hauled, all sails set, and moderate gales; no lee-way.
- 2 Blow fresh, small sails taken in; 1 point lee-way.
- 3 Top-sails close reefed; 2 points.
- 4 One top-sail handed; $2\frac{1}{2}$ points.
- 5 Both top-sails taken in; $3\frac{1}{2}$ points.
- 6 Fore courses handed; 4 points,
- 7 Trying

- 7 Trying under a mainfail ; 5 points.
- 8 Main and fore courses taken in ; 6 points.
- 9 Trying a hull with all sails handed ; 7 points.
- 10 When lying too, under a mainfail, mizen, &c. her coming up and falling off should be well observed ; then the course to be corrected, must be between the 2 points so coming up and falling off.

C O R O L L A R Y.

Hence, and by the variation of the compass, a ship's true course may be found ; yet as many accidents attend a ship's sailing, such as unknown currents, want of care at the helm to keep her steady, the different rates of velocity between the time of heaving the log, sudden squalls of wind, &c. &c. the latitude by account will frequently differ from that attained by observation ; and when this happens, great care must be taken to correct the ship's reckoning after the following manner, for by it the artist may always correct, whenever the latitude by account differs from that obtained by observation, whence the true place of a ship may at any time be found, and every artist should be very careful, and spare no pains in performing it in the most accurate manner possible, since not only credit, but also the lives and safeties of all on board depend thereon.

* * In taking your departure from any land, the back bearing (that is the point opposite to the bearing) and distance you judge yourself from it, must be considered as a course and distance, and corrected as such, allowing the variation upon it ; likewise the setting of currents, swells,

&c.

&c. &c.
them,
above.

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&c. &c. and the distance you suppose yourself driven by them, must be considered as a course and corrected as above.

N. B. The following rules for correcting the dead reckoning by an observation, I shall work by inspection from the difference of latitude and departure table; as by it, will be sufficient to shew the learner the use of this table in working any question in plane, traverse, middle latitude, or Mercator's sailings, which method (for the sake of expedition) is chiefly used at sea, in working a day's work, or keeping a ship's reckoning; however I recommend to every artist to work it mathematically, and by a constant practice of it, he will find no great deal of difference respecting the expedition; whereby by working it mathematically, he may be assured of exactness and truth, but by inspection it is impossible to do it with so much certainty.

RULES for CORRECTING the DEAD RECKONING by an OBSERVATION by INSPECTION.

C A S E Ist.

When the course by dead reckoning (or by account) is near the meridian, that is, less than 3 points or 33° . the error is then supposed to arise from the distance, because a small error in the course will cause but very little difference in the latitude.

R U L E.

R U L E.

With the course found by dead reckoning, and the meridian difference of latitude by observation, find the difference of longitude.

E X A M P L E.

Yesterday at noon, by observation, we were in latitude $49^{\circ}.41'$ north, and this noon in $48^{\circ}.21'$ north, when our dead reckoning gave 91 miles of southing, and 42 miles of westing: Required the true difference of longitude?

Look into the table of difference of latitude and departure, for 91 lat. and 42 dep. the nearest to this (at the top) is 25 degrees, which is equal to the course, then with the meridian difference of latitude between the observations, which is 122 lat. and the course 25 degrees, you have for dep. (equalling your difference of longitude) $57'.1$ your true difference of longitude.

C A S E II.

When the course by dead reckoning is more than 3 points, or 33 degrees, and less than 5 points, or 56° , the error may then arise partly in the distance, and partly in the course, to correct for this, observe as follows:

R U L E.

Find the course and distance by account, then with the difference of latitude by observation, and distance by account, find a new departure, which add to the departure found

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found by dead reckoning, the half sum thereof will give the true departure; again, with the true departure and difference of latitude by observation, find the true course; then with the true course and meridian difference of latitude between the observations find the difference of longitude, which will be the true difference of longitude as required.

E X A M P L E.

Yesterday at noon, by observation, we were in latitude $48^{\circ}.21'$ north, and this noon in latitude $47^{\circ}.10'$ north, having by account made 60 miles of southing, and 54 of westing: Required the true difference of longitude?

Look into the table of difference of latitude and departure, for 60 latitude and 54 dep. over which you will find 42 degrees equal to the course, and in the distance column is 81 equalling the distance; again with the distance 81 and difference of latitude (between the two observations) equalling 71, against this in the dep. column is 39.3, which being added to 54 (the dep. by dead reckoning) is equal to 93.3 the half of which is 46.6 the true departure; then with the true departure 46.6, and the difference of latitude by observation 71, the true course is 33 degrees, and dist. 85; with this course 33 degrees, and the merid. diff. of latitude between the two observations, which is 106, I find the departure is 68.6 equal to the true difference of longitude as required.

X

CASE

C A S E III.

When the course by dead reckoning is near the parallel of east and west, that is, more than 5 points, or 56 degrees, the error must then in general result from the course; because an error in the distance must be very large to make any considerable difference in the latitude.

R U L E.

Find the distance by dead reckoning, then with the distance and difference of latitude by observation, find a course, with this course and the meridian difference of latitude between the two observations, find the true difference of longitude.

E X A M P L E.

Yesterday at noon, by observation, we were in latitude $47^{\circ} 10'$ north, to-day at noon by observation we find ourselves in latitude $45^{\circ} 58' N$, when by account we have made but 58 miles of southing, and 120 of westing: Required the true diff. of longitude.

With the diff. of latitude 58, and dep. 120, I find in the table the distance to be 133 nearly, then with 133 the dist. and 72 lat. (by observation) the true course is 57° ; again with this course 57° , and the merid. difference of latitude between the two observations, which is 104 lat. against this I find in the dep. column 160.2, which is the true diff. of longitude required.

To

To CORRECT for SEVERAL DAYS.

R U L E.

Take the whole of the northings, southings, eastings, and westings since your last observation, as also for the day you correct on, and bring them into a traverse table, which will give you the whole difference of latitude and departure since your last observation; with this difference of latitude and departure, find a course, and observe which of the preceding cases it falls under, then correct by that case as directed.

EXERCISING EXAMPLES of DAYS WORKS.

Yesterday noon we were in lat. $48^{\circ}.20'N.$ and long. $8^{\circ}.30'W.$ and we have sailed till this day noon as per log. Required the course and dist. made good, with the lat. and long. the ship is in, also the bearings and dist. of Ushant?

N. B. H. stands for Hour, K. for knot or mile, and F. for Fathom. — 7 Fathoms make 1 Knot.

The LOG BOARD.						
H.	K.	F.	Courses.	Winds.	Lee-way	Remarks, &c.
1	3	4	NW.	NNE.	$1\frac{1}{2}$	
2	3	4				
3	3	4				
4	3	4				
5	4	0				
6	4	—				
7	4	—				
8	4	6				
9	4	2	NWbyW.	NbyE.	1	Variation $1\frac{1}{2}$ Point W.
10	4	2				
11	4	2				
12	5	—				
1	5	—				
2	5	—				
3	4	6				
4	4	4				
5	4	—				
6	4	—				
7	4	2				
8	4	2				
9	4	2				
10	4	4				
11	4	4				
12	4	4				

Course

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distance

Courses corrected.	Points.	Dist.	Northing.	Southing.	Easting.	Westing.
WbyN.	7	31	6.0	—	—	30.4
WNW $\frac{1}{2}$ W.	6 $\frac{1}{2}$	28	8.1	—	—	26.8
WbyN $\frac{1}{2}$ W.	7 $\frac{1}{2}$	44	4.3	—	—	43.8
			18.4			101.0

$$\begin{array}{lcl}
 \text{As diff. lat.} = 18'.4 & = & \text{As f. cou.} = 79^\circ.41' = \\
 \text{.. radius} = 90^\circ & = & \text{.. depart.} = 101' = \\
 \therefore \text{depart.} = 101' & = & \therefore \text{radius} = 90^\circ = \\
 \text{.. t. course} = 79^\circ.41' & = & \text{.. dist.} = 102'.7 =
 \end{array}$$

Merid. Parts.

$$\begin{array}{lcl}
 \text{Yesterday's la. } 48^\circ 20' \text{ N} & = 3322 & \text{As rad.} = 90^\circ = \\
 \text{To-day's d. la. } 00.18 \text{ N} & = & \text{.. MD. lat.} = 27' = \\
 \text{To-day's la. in } 48.38 \text{ N} & = 3349 & \therefore \text{t. cour.} = 79^\circ 41' = \\
 \text{MD. lat. } 27 & & \therefore \text{diff. lon.} = 148.3 = \\
 & & \underline{2.28 \text{ W.}}
 \end{array}$$

Yesterday's long. $8^\circ.30'$ WestThis day's diff. long. 2.28 WestThis day's long. in 10.58 West

To find the BEARING and DISTANCE of Ushant, it is thus:

Merid. Parts.

$$\begin{array}{lcl}
 \text{Ship's lat. in } 48^\circ.38' \text{ N} & = 3349 & \text{Ship's long. in } 10^\circ.58' \text{ West} \\
 \text{Ushant's lat. } 48.30 \text{ N} & = 3337 & \text{Ushant's long. } 5.05 \text{ West} \\
 \text{PD. lat. } 00.08 \text{ MD. la. } 12 & & \underline{5.53} \\
 & & \underline{60} \\
 & & \text{Diff. lon. miles } \underline{353}
 \end{array}$$

$$\begin{array}{lcl}
 \text{As MD. lat.} = 12' & = & \text{As radius} = 90^\circ = \\
 \text{.. radius} = 90^\circ & = & \text{.. PD. lat.} = 8' = \\
 \therefore \text{di. lon.} = 353' & = & \therefore \text{sec. bear.} = 88^\circ 03' = \\
 \text{.. t. bear.} = 88^\circ.03' & = & \text{.. dist.} = 235'.1 =
 \end{array}$$

Anf. Course N. $79^\circ.41'$ W. distance 102.7 miles, latitude in $48^\circ.38'$ N. longitude $10^\circ.58'$ W. Ushant S. $88^\circ.03'$ E. distance 235.1 miles

X 3

We

We were yesterday noon in lat. $20^{\circ}.30'$ S. and long. $5^{\circ}.20'$ E. and have failed 'till this day noon, as per log. in a current setting S. $1\frac{1}{2}$ mile per hour: Required the course and distance made good, also the ship's place, with the bearing and distance of Cape Good Hope.

H.	K.	F.	Courfes.	Winds	Lee-way.	Remarks, &c.
1	4	4	SbyE.	EbyS.	1	
2	4	4				
3	4	2				
4	4	—				
5	4	—				
6	4	4				
7	4	6	SSE.	Eaft.	$\frac{3}{4}$	
8	5	—				
9	5	—				
10	5	2				
11	5	4				
12	5	4				
1	5	3				$\frac{1}{2}$
2	5	2				
3	5	2				
4	5	6				
5	6	—				
6	6	—				
7	6	2				
8	6	1				
9	6	3				
10	6	4				
11	6	4	Variation 1 Point W.			
12	6	6				

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Ans.

 $23^{\circ}.04'$

distance

Courses corrected.	Points.	Dift.	Nothing.	Southing.	Easting.	Westing.
Sby E.	1	31	—	30.4	6.0	—
SSE $\frac{1}{4}$ E.	2 $\frac{1}{4}$	48	—	43.4	20.5	—
SSE $\frac{1}{2}$ E.	2 $\frac{1}{2}$	51	—	45.0	24.0	—
Sby E.	1	36	—	35.3	7.0	—

154.1 $\searrow$ 57.5

As diff. lat. = 154'.1 = As f. cou. = 20°.28' =
 .. radius = 90°. = .. depart. = 57'.5 =
 :: depart. = 57'.5 = :: radius = 90°. =
 .. t. cou. = 20°.28' = .. dist. = 164'.4 =

M. parts.

Yesterday's lat. 20°.30' S. 1257 As radius = 90°. =
 This day's d. lat. 2°.34' S. .. m. d. lat. = 166' =
 Ship's lat. in 23°.04' S. 1423 :: t. course = 20°.28' =
 m. d. lat. 166 .. diff. long. = 61.96 =

Yesterday's longitude 5°.20' east.

This day's diff. long. 1°.02' east.

Ship's long. in 6°.22' East.

To find the bearing and distance of Cape Good Hope, it is thus:

M. parts.

Ship's lat. in 23°.04' S. 1423 Ship's long. in 6°.22' east.
 The cape's lat. 34°.29' S. 2207 Cape's long. 18°.23' east.
 Diff. lat. 11°.25' S. Diff. long. 12°.01' east.
 60 m. d. lat. 784 60
 P. d. lat. 685 721

As m. d. lat. = 784' = As radius = 90°. =
 .. radius = 90°. = .. p. d. lat. = 685' =
 :: diff. long. = 721' = :: sec. bear. = 42°.36' =
 .. t. bear. = 42°.36' = .. distance = 930'.6 =

Anf. Course S. 20°.28' E. distance 164.4 miles, latitude in 23°.04' S. longitude 6°.22' E. Cape Good Hope, S. 42°.36' E. distance 930.6.

Being yesterday at noon in lat. $46^{\circ}.30' N.$ and long. $10^{\circ}.20'$ west, at 8 PM. the sun was observed to set west $53^{\circ}.10' N.$ declination $22^{\circ}.30' N.$ and we have sailed 'till this day noon, as per log, the tide having all the time set SSE. $2\frac{1}{4}$ per hour: Required the course and distance made good, also the ship's place, with the bearing and distance of Cape Finisterre.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks, &c.
1	6	—	SWbyW $\frac{1}{4}$ W.	NW.	0	
2	6	—				
3	6	—				
4	6	—				
5	6	2				
6	6	2				
7	6	2				
8	6	2				
9	5	4	SWbyS.	WbyN.	$\frac{1}{2}$	The sun set W. $53^{\circ}.10'$ to the Northward.
10	5	2				
11	5	2				
12	5	2				
1	5	2	SSW $\frac{1}{2}$ W.	W $\frac{1}{2}$ N.	1	Variation per amplitude $1\frac{3}{4}$ point W.
2	5	2				
3	5	2				
4	4	4				
5	4	4				
6	4	3				
7	4	3				
8	4	3				
9	4	2				
10	4	2				
11	4	2				
12	4	2				

Course

SW

S $\frac{1}{4}$ WS $\frac{1}{4}$ N

SE

Lat. at
diff. la
allowi
lat. in

co. lat

As diff

.. radi

:: dep

.. t. co

Yester

diff. la

ship's l

To fir

Ship's l

Cape F

p. d

As m. d

.. radi

:: diff.

.. t. be

Ans. C

 $10^{\circ}.11'$

Courses corrected.	Points.	Dist.	Northing.	Southing.	Easting.	Westing.
SW.	4	49	—	34.6	—	34.6
S $\frac{3}{4}$ W.	$\frac{3}{4}$	37	—	36.6	—	5.4
S $\frac{1}{4}$ E.	$\frac{1}{4}$	39	—	39.0	1.9	—
SE by S $\frac{1}{4}$ E.	$3\frac{3}{4}$	66	—	48.9	44.3	—
				159.1	46.2	40.0
					40.0	
					6.2	

Lat. at noon $46^{\circ}.30' N.$ As f. co. lat. $= 44^{\circ}.21' =$
 diff. lat. at 8 P.M. } $0^{\circ}.51' S.$.. radius $= 90^{\circ} =$
 allowing for cur. } :: f. $\odot$ dec. $= 22^{\circ}.30' =$
 lat. in at 8 P.M. $45^{\circ}.39' N.$.. f. t. amp. $= 33^{\circ}.12' =$
 90° mag. amp. $= 53^{\circ}.10' =$
 co. lat. at 8 P.M. $44^{\circ}.21'$ variation $19^{\circ}.58' W.$

As diff. lat. $= 159^{\circ}.1' =$ As f. courf. $2^{\circ}.14' =$
 .. radius $= 90^{\circ} =$.. depart. $= 6'.2 =$
 :: depart. $= 6'.2 =$: radius $= 90^{\circ} =$
 .. t. course $= 2^{\circ}.14' =$.. dist. $= 159^{\circ}.1' =$

Yesterd. lat. $46^{\circ}.30' N = 3159$ As rad. $= 90^{\circ} =$
 diff. lat. $2^{\circ}.39' S =$.. m. d. lat. $= 226' =$
 ship's lat. in $43^{\circ}.51' N = 2933$:: t. course $= 2^{\circ}.14' =$
 m. d. lat. $226'$.. diff. long. $= 8.814 =$

Yesterday's long. $10^{\circ}.20' W.$

Difference long. $0^{\circ}.09' E.$

Ship's long. in $10^{\circ}.11' W.$

To find the Bearing and Distance of Cape FINISTERRE.

M. parts.

Ship's lat. in $43^{\circ}.51' N = 2933$ Ship's long. in $= 10^{\circ}.11' W.$
 Cape Fin. lat. $42^{\circ}.52' N = 2852$ Cape's long. $= 9^{\circ}.17' W.$
 p. d. lat. $00^{\circ}.59' m. d. lat. 81$ $0^{\circ}.54$

As m. d. lat. $= 81' =$ As radius $= 90^{\circ} =$
 .. radius $= 90^{\circ} =$.. p. d. lat. $= 59' =$
 :: diff. long. $= 54' =$:: sec. bear. $= 33^{\circ}.41' =$
 .. t. bear. $= 33^{\circ}.41' =$.. distance $= 70'.9 =$

Anf. Course $S 2^{\circ}.14' E.$ dist. 159 miles, lat. in $43.51 N.$ lon.
 $10^{\circ}.11' W.$ Cape Finisterre $S. 33^{\circ}.41' E.$ dist. 70.9 miles.

We were yesterday noon, in latitude $42^{\circ}.30'$ N. and longitude $11^{\circ}.30'$ west, and this morning at 6 AM. we observed the sun's altitude to be $14^{\circ}.30'$, when his declination was $15^{\circ}.20'$ north, he then bearing E. $9^{\circ}20'$ S. and we have sailed till this day noon, as per log, in a swell from the SW. for which we allow $12'$ for the 24 hours: Required the course and distance made good, also the ship's place, with the bearing and distance of Oporto.

H.	K.	F.	Courfes.	Winds	Lee-way.	Remarks, &c.
1	5	5	EbyN.	SSE.	$\frac{1}{2}$	
2	5	4				
3	5	6				
4	5	6				
5	6	—				
6	6	—				
7	6	4	Eaft.		$\frac{1}{2}$	
8	6	4				
9	6	3				
10	6	4				
11	6	4				
12	7	—				
1	7	—			0	
2	7	1				
3	7	3				
4	7	2				
5	6	4				
6	6	—				
7	5	4	$E\frac{1}{2}N.$	$SSE\frac{1}{2}E.$	$\frac{1}{2}$	The fun's alt. $14^{\circ}.30'$ dec. $15^{\circ}.20'$ N.
8	5	2				
9	5	2				
10	5	—				
11	5	—				
12	5	—				
						Variation $1\frac{1}{2}$ point W per azimuth.

Courses

NEby

ENE.

ENE.

NEby

NNE.

Co. alt

S. co. l

S. co. a

S. $\frac{1}{2}$ fur

S. rem.

Courses corrected.	Points.	Dist.	Northing.	Southing	Easting.	Westing.
NE by E.	5	41	22.8		34.1	
ENE.	6	26	10.		24.0	
ENE $\frac{1}{2}$ E.	$6\frac{1}{2}$	48	13.9		45.9	
NE by E $\frac{1}{2}$ E.	$5\frac{1}{2}$	31	14.6		27.3	
NNE $\frac{1}{2}$ E.	$2\frac{1}{2}$	12	10.6		5.7	
			71.9		130.0	

Lat. at noon $42^{\circ}.30' N.$

Diff. lat. at 6 AM. al. }
 lowing for the swell } $0.54 N.$

Lat. in at 6 AM. $43.24 N.$
 90

Co. latitude 46.36

Co. altitude 75.30

Sun's distance 74.40

$\frac{1}{2}) 196.46$ sum

$98.23 \frac{1}{2}$ sum

74.40 sun's dist.

23.43 remainder

90°
 $14.30'$ alt.

90°
 $15.20'$ dec,

Co. alt. 75.30 74.40 $\odot$ dist. from the pole.

S. co. lat. $= 46^{\circ}.36' = 9.86128$ its ar. co. $= 0.13872$

S. co. alt. $= 75.30 = 9.98594$ ditto $= 0.01406$

S. $\frac{1}{2}$ sum $= 98.23$ $= 9.99533$

S. rem. $= 23.43$ $= 9.60446$

$\frac{1}{2}) 19.75257$

co. sine $41^{\circ}.14' = 9.87628$

2

True az. N. $82.28 E.$

90

True az. E. $7.32 N.$

Mag. az. E. $9.20 S.$

Variation $16.52 W.$

As diff. lat. $= 71'.9 =$	As f. course $= 62^\circ.18' =$
.. radius $= 90^\circ =$	.. depart. $= 137' =$
:: depart $= 137' =$	:: radius $= 90^\circ =$
.. t. cou. $= 62^\circ.18' =$	.. distance $= 154'.7 =$

Merid. Parts.

Yesterd. lat. $42^\circ.30' N = 2822$	As radius $= 90^\circ =$
Diff. lat. 1.12	.. MD. lat. $= 99' =$
	:: t. course $= 62^\circ.18' =$
Ship's lat. in $43^\circ.42' N = 2921$	.. diff. long. $= 188'.5 =$
MD. lat. 99	$3^\circ.08' =$

Yesterday's long. $11^\circ.30' W.$
 Difference long. $3.08 E.$

Ship's long. in $8.22 W.$

To find the Bearing and Distance of OPORTO, it is thus:

Merid. Parts.

Ship's lat. in $43^\circ.42' N = 2921$	Ship's long. in $= 8^\circ.22' W.$
Oporto's lat. $41^\circ.10' N = 2715$	Oporto's long. $= 8^\circ.27' W.$
2.32 MD. la. 206	D. long. $0.5 W.$
60	
P.D. lat. 152	

As M. diff. lat. $= 206' =$	As radius $= 90^\circ =$
.. radius $= 90^\circ =$	.. PD. lat. $= 152' =$
:: diff. long. $= 5' =$	:: sec. bear. $= 1^\circ.24' =$
.. t. bearing $= 1^\circ.24' =$	.. distance $= 152'.1 =$

Anf. Course N. $62^\circ.18' E.$ dist. 154.7 miles, latitude in $43^\circ.42' N.$ longitude $8^\circ.22' W.$ Oporto S. $1^\circ.24' W.$ distance 152.1 miles.

A LOG.

A
L O G
O F A
S H I P ' s V O Y A G E ,
F R O M T H E
D O W N S T O G I B R A L T A R ,

In his MAJESTY's Ship

The C U M B E R L A N D :

K E P T B Y

J O H N D I L I G E N T , M A S T E R .

Y

The LOG BOARD.						
H.	K.	F.	Courfes.	Winds.	Lee-way.	Remarks, &c. Tuesday 15th Auguft, 1786.
1						Fine and moderate weather, Hove short.
2						
3						
4						
5			WbyN.	North.		Weighed and failed.
6						
7						
8						
9						Unbent the cables and flowed the anchor.
10						
11						
12						
1			West.			Do. weather.
2						
3						
4						
5						Beachy-head north a- bout 8 miles.
6			WbyN.	NbyE.		
7						
8						
9						Fresh gales &-fqually.
10						
11						
12						
						Bembridge Point NW by W. 4 leagues.

The LOG BOARD.

H.	K.	E.	Courses.	Winds	Lee-way.	Remarks, &c. Wed. 16th Aug. 1786.
1	7	4	WbyN.	North.		Fresh gales and fair.
2	7	4				
3	7	5	W $\frac{1}{2}$ N.			
4	7	5				
5	7	4	WNW.			The Bill of Portland NW.
6	7	4				
7	7	6				
8	7	3				
9	6	6				Do. weather.
10	6	4				
11	6	2				
12	6	—				
1	6	6				The Start WNW $\frac{1}{2}$ W. 5 or 6 leagues.
2	5	4	WNW $\frac{1}{2}$ N.	NbyE.		
3	5	2				
4	5	—				
5	4	2				Lizard NW.
6	—	4				
7	6	—				
8	6	4				
9	6	4				
10	6	5		N $\frac{1}{2}$ E.		
11	6	5				
12	6	5				

The LOG BOARD.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks, &c. Thurl. 17th August, 1786.		
1	6	4	W S W.	North.	$\frac{1}{2}$	Brisk winds and cloudy		
2	6	4						
3	6	2	SW by W	NNW.				
4	6	—						
5	5	6	SW.	NW.		Moderate and fair, at 4		
6	5	4				the Liz. bore NE by N $\frac{1}{2}$		
7	4	4				E. dist. 5 leagues, from		
8	4	—				which we took our de-		
9	3	5			1	parture.		
10	3	2						
11	3	6						
12	4	2				Do. weather, spoke the		
1	5	—				Brig Kingston, bound		
2	5	2			$\frac{1}{2}$	to Oporto, J. Wheeler,		
3	5	—				Master.		
4	5	4						
5	6	—						
6	6	4						
7	6	6			0	Brisk winds & cloudy.		
8	7	—						
9	7	2						
10	7	—				Variation 2 points		
11	7	4				West.		
12	7	4						
Course.	Dist. in miles.	Dist. Lat.	Dep.	Lat. in per. ac.	Lat. in per ob.	Long. in	Mer. Dist.	Bearings and Dist. at noon.
$57^{\circ}55'$ W.	125.8	119.6	38.7	$47^{\circ}58'N$	$47^{\circ}58'$	$6^{\circ}14'W$	38.7	Usha. $56^{\circ}19'E$ Dist. 55.90 miles.

N. B. The Lizard's back bearing from which we took our departure, being equal to the first course, after allowing the variation upon it, the distance is therefore added to the distance sailed on the first course, which equal 35 miles, viz. 20' and 5 leagues.

TRAVERSE TABLE.

Courses corrected.	Points.	Dist.	Northing.	Southing.	Easting.	Westing.
Sby $W\frac{1}{2}W$.	$1\frac{1}{2}$	35	—	33.5	—	10.2
Sby W.	1	20	—	19.6	—	3.9
Sby $W\frac{1}{2}W$.	$1\frac{1}{2}$	28	—	26.8	—	8.1
SSW.	2	43	—	39.7	—	16.5
				119.6		38.7

As d. lat. $= 119.6 = 7,92227$ | As f. co. $= 17^{\circ}.55' = 0,51197$
 .. radius $= 90^{\circ} = 10,00000$ | .. dep. $= 38'.7 = 1,58771$
 :: depart. $= 38.7 = 1,58771$ | :: radi. $= 90^{\circ} = 10,$
 .. t. co. $= 17^{\circ}.55' = 9,50998$ | .. dist. $= 125'.8 = 2,09968$

Yest. lat. $= 49^{\circ}.58' N. = 3471$ | Radius $= 90^{\circ} = 0,00000$
 to day's d. $= 2.00 S.$ | .. m. d. lat. $= 182 = 2,26007$
 Ship's la. in $47.58' N. = 3289$ | :: t. course $= 17.55 = 9,50962$
 M. D. lat. 182 | .. diff. long. $= 58.8 = 1,76969$

Yesterday's longitude $5^{\circ}.15' W.$

This day's diff. long. $0.59 W.$

Ship's long. in $6.14 W.$

To find the bearing and distance of Ushant, it is thus :

Ship's lat. $47^{\circ}.58' N. = 3289$	Ship's long. $6^{\circ}.14' W.$
Ushant's lat. $48.29 N. = 3335$	Ushant's long. $5.5 W.$
P. D. lat. $0.31 = M. D. 46'$	1.9
	60
	Diff. long. 69 miles

As m. d. lat. $= 46 = 8,33724$ | As radius $= 90^{\circ} = 0,00000$
 .. radius $= 90^{\circ} = 10,00000$ | .. p. d. lat. $= 31 = 1,49136$
 :: diff. long. $= 69 = 1,83885$ | :: fe. bear. $= 56.19 = 10,25602$
 .. t. bear. $= 56.19 = 10,17609$ | .. distance $= 55.90 = 1,74738$

The LOG BOARD.

H.	F.	F.	Courses	Winds.	Lee-way.	Remarks, &c. Friday, 18th Aug. 1786.			
1	7	6	SW.	NW.	0	Brisk winds and clear			
2	7	4							
3	7	6							
4	7	4							
5	7	4							
6	7	4		NWbyW	$\frac{1}{2}$				
7	7	4				Do. and cloudy.			
8	7	2							
9	7	2							
10	7	2							
11	7	3							
12	7	2							
1	7	—				Moderate and cloudy.			
2	7	—							
3	6	6							
4	6	6							
5	6	6							
6	6	4		WNW.	1				
7	6	4				Variation 2 points W.			
8	6	—							
9	6	2							
10	6	—							
11	5	4							
12	5	—							
Course	Diff. in Miles.	Diff. Lat.	Dep.	Lat. in per ac.	Lat. in per ob.	Lon. in.	Me. Diff.	Bearings and Dist. at noon.	
S. 17° W.	166.6	159.3	48.7	8 / 45.19		7.25 W	87.4 W.	C. Ortegat S. 6.12 W. dist. 92.54 m.	

T R A.

TRAVERSE TABLE.

Courses corrected.	Points.	Dist.	Northing.	Southing.	Easting.	Westing.
SSW.	1	39		36.0		14.9
SbyW $\frac{1}{2}$ W.	$1\frac{1}{2}$	93		83.0		27.0
SbyW.	1	35		34.3		6.8
				159.3		48.7

As d. lat. = 159.3 = 7,79778 | As f. co. = 17° = 0,53407
 .. radius = 90° = 10,00000 | .. depart. = 48.7 = 1,68753
 :: dep. = 48.7 = 1,68753 | :: radius = 90° = 10,00000
 .. t. co. = 17° = 9,48531 | .. dist. = 166.6 = 2,22160

Yesterday's lat. 47° 58' N. = 3289 | As rad. = 90° = 0,00000
 To-day's d. la. 2 39 S. = | .. MD. la. = 232 = 2,36549
 Ship's lat. in 45 19 N. = 3057 | :: t. cou. = 17° = 9,48534
 M.D. lat. 232 | :: d. lon. = 70'.93 = 1,85083

Yesterday's long. 6°.14' West
 This day's diff. long. 1.11 West
 Ship's long. in 7.25 West

To find the BEARING and DISTANCE of Cape Ortegal.

Ship's lat. 45° 19' N. = 3057 | Ship's long. 7°.25' West.
 Cape's lat. 43 47 N. = 2928 | Cape's long. 7.39 West:
 PD. lat. 1 32 MD. la. 129 | Diff. lon. 0.14 West.

As M.D. la. = 129 = 7,88941 | As radius = 90° = 0,00000
 .. radius = 90° = 10,00000 | .. PD. la. = 92 = 1,96379
 :: di. lon. = 14 = 1,14613 | :: fe. bear. = 6°.12' = 10,00255
 .. t. bear. = 6°.12' = 9,03554 | .. dist. = 92.54 = 1,96684

The

The LOG BOARD.

H.	K.	F.	Courfes.	Winds	Lee-way.	Remarks, &c. Satur. 19th Auguft, 1786.			
1	5	4	WSW.	NW.	1	Moderate, and clear.			
2	5	2							
3	5	2							
4	5	—							
5	4	6	West.	NNW.	1½				
6	4	6							
7	4	4							
8	4	6							
9	4	4							
10	4	2							
11	4	2				Do. weather.			
12	4	6							
1	4	6							
2	4	6		North.	1				
3	5	—							
4	5	2							
5	5	2							
6	5	—							
7	5	2							
8	5	4							
9	5	4				People employed fet- ting up the rigging, str. breezes and cloudy.			
10	6	—							
11	6	6							
12	7	—							
						Variation 1½ Point W.			
Courfe.	Diff.	Diff. lat.	Dip.	Lat. in per ac.	Lat. in per ob.	Long. in.	Meri. Diff.	Bearings and d. at Noon.	
557.8w	123.5	67	103.7	44.12N	44.12N	9.50 W.	191.1 W.	C. Fin. 816°.34½ d. 83.47 miles.	

T R A-

TRAVERSE TABLE.

Courses corrected.	Points.	Dist.	Northing.	Southing.	Easting.	Westing.
SWbyS $\frac{1}{2}$ W.	$3\frac{1}{2}$	21	—	16.2	—	13.3
SWbyW.	5	42	—	23.3	—	34.9
SWbyW $\frac{1}{2}$ W.	$5\frac{1}{2}$	42	—	19.8	—	37.0
WSW.	6	20	—	7.7	—	18.5
				67.0		103.7

As diff. lat. $= 67' = 8.17393$ As f. courf. $57^{\circ}.8' = 0.07575$
 .. radius $= 90^{\circ} = 10,00000$.. depart. $103.7 = 2.01578$
 :: depart. $= 103'7 = 2.01578$: radius $90^{\circ} = 10,00000$
 .. t. co. $= 57^{\circ}.8' = 10,18971$.. dist. $123.5 = 2.09153$

Yesterd. lat. $45^{\circ}.19' N = 3057$ As rad. $= 90^{\circ} = 0.00000$
 this day's d.l. $1 \cdot 7 S. =$.. m. d. l. $= 94' = 1.97313$
 ship's lat. in $44 \cdot 12 N = 2963$:: t. cou. $= 57^{\circ}.8' = 10,18970$
 m. d. lat. 94 .. d. long. $= 145.5 = 2.16283$

Yesterday's long. $= 7^{\circ}.25' W.$
 This day's diff. lon. $= 2 \cdot 25 W.$
 Ship's long. in $9 \cdot 50 W.$

To find the Bearing and Distance of Cape FINISTER.

Ship's lat. $44^{\circ}.12' N. = 2963$ Ship's long. $9^{\circ}.50' W.$
 Cape's lat. $42 \cdot 52 N. = 2852$ Cape's long. $9 \cdot 17 W.$
 p. d. lat. $1 \cdot 20 m. d. lat. 111$ $\cdot 33 W.$

As m. d. lat. $= 111 = 7,95468$ As radius $= 90^{\circ} = 0.00000$
 .. radius $= 90^{\circ} = 10,00000$.. p. d. lat. $= 80' = 1.90309$
 :: diff. long. $= 33 = 1.51851$:: fe. bear. $16^{\circ}.34' = 10,01841$
 .. t. bear. $16^{\circ}.34' = 9.47319$.. dist. $= 83.47 = 1.92150$

The

The LOG BOARD.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks, &c. Sunday, 20 Aug. 1786.		
1	7	5	WSW.	NW.	$\frac{1}{2}$	Strong gales & rain		
2	7	5						
3	7	5						
4	8	—						
5	8	2						
6	8	—						
7	8	—	SW.			Do. weather, and cloudy.		
8	8	2						
9	8	2						
10	8	4						
11	8	2						
12	—	—						
1	—	—				up NW by W. off North Drift $1\frac{1}{2}$ per hour.	6	Strong gales and cloudy; lay too under reef mainsail upon the larboard tack.
2	—	—						
3	—	—						
4	—	—						
5	—	—						
6	—	—						
7	—	—	up SE by S off ESE drift 1 mile per h.	5	Fresh gales & cloudy; set more sail.			
8	—	—						
9	—	—						
10	6	2						
11	6	2						
12	6	3						
			SW.	WNW	2	Do. weather & fair		
						Variation $1\frac{1}{2}$ W.		

Course.	Dist.	Diff. Lat	Dep.	Lat. in per. ac.	Lat. in per. ob.	Lon. in	Meri. Dist.	Bearing and dist. at Noon.
S. 49 W.	85	56	64.2	43.02 N	43.16 N	11.20	255.5 W.	C. St. Vin. S 15° 43' E. di. 388.6 m.

T R A.

TRAVERSE TABLE.

Courses corrected.	Points	Diff.	Northing	Southing	Easting.	Westing.
SW.	4	89		62.9		62.9
NNE.	2	10.5	9.7		4.0	
NE by E.	5	3	1.7		2.5	
S $\frac{1}{2}$ W.	$\frac{1}{2}$	19		18.9		1.9
			11.4	81.8	6.5	64.8
				11.4		6.5
				70.4		58.3

As diff. lat. = $70.4 = 8,15243$ As f. cou. = $39^{\circ}.38' = 0,19427$
 .. radius = $90^{\circ} = 10,00000$.. dep. = $58.3 = 1,76567$
 :: depart = $58.3 = 1,76567$:: radius = $90^{\circ} = 10,00000$
 .. t. cou. = $39^{\circ}.38' = 9,91810$.. distance = $91.4 = 1,96099$

Merid. Parts.

Yesterd. lat. $44^{\circ}.12' N = 2963$ As radius = $90^{\circ} = 0,00000$
 This day's d. l. $1.10 S =$.. MD. l. = $97' = 1,98677$
 This d's l. in $43.02 N = 2866$:: t. cou. = $39^{\circ}.38' = 9,91816$
 MD. lat. 97 .. diff. lon. = $80.34 = 1,90493$

N. B. The lat. by acc. and that of obl. not agreeing, I correct this day's work by case 2d, page 216 which I find as follows, viz. true course S. $49^{\circ}.0' W$. diff. 85 miles, and true diff. long. 89.8 miles

Yesterday's long. $9^{\circ}.50' W$.

This day's diff. long. $1.30 W$.

Ship's long. in $11.20 W$.

To find the Bearing and Distance of Cape St. Vincent.
 Ship's lat. $43^{\circ}.16' N = 2885$ Ship's long. = $11^{\circ}.20' W$.
 C. St. Vin. l. $37.02 N = 2395$ Cape's long. = $9.02 W$.
 P.D. lat. $6.14 MD. la. 490$ D. long. $2.18 W$.
 60
 374
 138

As m. diff. lat. = $490 = 7.30970$ As radius = $90^{\circ} = 0,00000$
 .. radius = $90^{\circ} = 10,00000$.. PD. lat. = $374 = 2,57287$
 :: diff. long. = $138 = 2,13988$:: sec. bea. $15^{\circ}.43' = 10,01655$
 .. t. bea. = $15^{\circ}.43' = 9,44958$.. dist. = $388,6 = 2,58942$

The LOG BOARD.

H.	K.	F.	Courfes.	Winds.	Lee-way	Remarks, &c.
1	6	3	SW.	WNW	1½	These 24 hours, fresh gales and fine weather
2	6	3				
3	6	5				
4	7	—				
5	6	5				
6	5	—				
7	7	—	NWbyW	1		
8	7	—				
9	7	2				
10	7	4				
11	7	—				
12	8	2				
1	8	2			1½	
2	8	3				
3	8	3				
4	8	3				
5	8	2				
6	8	2				
7	8	—				
8	8	—				
9	8	—				
10	8	2				
11	8	—				
12	8	2				
						People employed fet- ting up the rigging. Variation 1½ Point W.

Courfe.	Diff.	Diff.	Dep.	Lat. in	Lat. in	Long.	Meri.	Bearings and
		lat.		per. ac.	per ob.	in	dist.	dist. at noon.
518.56w	182.5	172.5	59.2	40.24N	40.23	12.39w	314.7	C. St. Vi. s 40° 04'E. d. 262.6

T R A.

TRAVERSE TABLE.

Courses corrected.	Points.	Dist.	Northing.	Southing.	Easting.	Westing.
Sby W.	1	47		46.1		9.2
Sby W $\frac{1}{2}$ W.	$1\frac{1}{2}$	22		21.1		6.4
SSW.	2	114		105.3		43.6
				172.5		59.2

As d. lat. = $172.5 = 7,76321$ As f. co. = $18^{\circ}.56' = 0,48883$
 .. radius = $90^{\circ} = 10,00000$.. depart. = $59.2 = 1,77232$
 :: dep. = $59.2 = 1,77232$:: radius = $90^{\circ} = 10,00000$
 .. t. co. = $18^{\circ}.56' = 9,53553$.. dist. = $182.5 = 2,26115$

Yesterd. lat. $43^{\circ}.16'N. = 2885$ As rad. = $90^{\circ} = 0,00000$
 To-day's d. la. $2.52 S. =$.. MD. la. = $231 = 2,36361$
 Ship's lat. in $40.24 N = 2654$:: t. cou. = $18^{\circ}.56' = 9,53533$
 M.D. lat. 231 :: d. lon. = $79'.24 = 1,89894$

Yesterday's long. $11^{\circ}.20' West$

This day's diff. long. $1.19 West$

Ship's long. in $12.39 West$

To find the BEARING and DISTANCE of Cape St. Vincent.

Ship's lat. $49^{\circ}.23'N = 2653$ Ship's long. $12^{\circ}.30' West.$
 Cape's lat. $37.00 N = 2395$ Cape's long. $9.2 West.$
 PD. lat. 3.21 MD. la. 258 $3.37 West.$
 60
 P. Diff. lat. 201 Diff. lon. $217 miles.$

As M.D. la. = $258 = 7,58838$ As radius = $90^{\circ} = 0,00000$
 .. radius = $90^{\circ} = 10,00000$.. PD. la. = $201 = 2,30320$
 : dif. lon. = $217 = 2,33646$:: sc. bear. = $40.04' = 10,11617$
 .. t. bear. = $40^{\circ}.4' = 9,92484$.. dist. = $262.6 = 2,96634$

Z

The

The LOG BOARD.

H.	F.	F.	Courses	Winds.	Lee-way.	Remarks, &c. Tuesday, 22d Aug. 1786.							
1	8	6	SSW.	WNW.	$\frac{1}{4}$	Strong gales and fair.							
2	8	6											
3	8	6											
4	9	—											
5	9	—											
6	9	—											
7	9	2											
8	9	—											
9	9	2											
10	9	1											
11	9	—											
12	9	—	WbyN.	$\frac{1}{2}$	Do. weather & cloudy.								
1	9	2											
2	9	—											
3	8	6											
4	8	6											
5	8	6											
6	8	4											
7	8	—											
8	8	—											
9	7	4											
10	7	2											
11	7	1		$\frac{3}{4}$	Fresh gales & cloudy.								
12	7	—											
								Variation $1\frac{1}{4}$ points W.					
Course	Dist. in Miles.	Diff. Lat.	Dep.	Lat. in per ac.	Lat. in per ob.	Lon. in.	M c . Dist.	Bearings and Dist. at noon.					
S 4.7 W.	206.2	205.3	14.8	36.59		12.58 N.	329.3	C. St. V. N. 89.02 E. dist. 177.5 m.					

T R A.

TRAVERSE TABLE.

Courses corrected.	Points.	Dist.	No. thing.	Southing.	Easting.	Welling.
$S\frac{1}{2}W.$	$\frac{1}{2}$	126	—	125.4		12.3
$S\frac{1}{4}W.$	$\frac{1}{4}$	51	—	50.9		2.5
S.	0	29	—	29.0		0.0
				205.3		14.8

As d. lat. = 205.3 = 7,68656 | As f. co. = $4^{\circ}.7'$ = 1,14395
 .. radius = 90° = 10,00000 | .. dep. = 14.8 = 1,17026
 :: depart. = 14.8 = 1,17026 | :: radi. = 90° = 10,00000
 .. t. co. = $4^{\circ}.7'$ = 8,85682 | .. dist. = 206.2 = 2,31421

Yest. lat. = $40^{\circ}.24'N.$ = 2654 | Radius = 90° = 0,00000
 to day's d. = 3.25 S. | .. m. d. lat. = 263 = 2,41996
 Ship's la. in $36^{\circ}.59'N.$ = 2391 | :: t. course = $4^{\circ}.7'$ = 8,85717
 M. D. lat. 263 | .. diff. long. = 18.93 = 1,27713

Yesterday's longitude $12^{\circ}.39'W.$

This day's diff. long. 0.19 W.

Ship's long. in $12^{\circ}.58'W.$

To find the bearing and distance of Cape St. Vincent

Ship's lat. $36^{\circ}.59'N.$ = 2391 | Ship's long. $12^{\circ}.58'W.$
 Cape's lat. $37^{\circ}.02'N.$ = 2395 | Cape's long. 9.2 W.
 P. D. lat. .3 = M. D. l. 4 | 3.56
 60
 Diff. long. 236 miles

As m. d. lat. = 4' = 9,39794 | As radius = 90° = 0,00000
 .. radius = 90° = 10,00000 | .. p. d. lat. = 3' = 0,47712
 :: diff. long. = 236 = 2,37291 | :: se. bear. $89^{\circ}.02'$ = 11,77206
 .. t. bear. = $89^{\circ}.02'$ = 11,77085 | .. distance = 177.5 = 2,24918

The

The LOG BOARD.									
H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks, &c. Wednes. 22d August, 1786.			
1	7	3	SE.	SW.	$\frac{1}{4}$	Fresh gales and hazy.			
2	7	6							
3	7	4							
4	7	3							
5	7	2							
6	7	3							
7	7	4	ESE.	SSW.	$\frac{1}{2}$	Fresh gales with rain.			
8	7	4							
9	7	—							
10	7	4							
11	7	—							
12	7	2							
1	7	4	ESE.	SSW.	$\frac{1}{2}$	Fresh gales and cloudy			
2	7	6							
3	8	—							
4	8	1							
5	8	1							
6	8	2							
7	8	2	ESE.	SSW.	$\frac{1}{2}$	Strong gales and fair.			
8	8	—							
9	8	—							
10	8	4							
11	8	6							
12	9	—							
Course.		Dist. in miles.	Diff. Lat.	Dep.	Lat. in per. ac.	Lat. in per ob.	Long. in	Mer. Dist.	Bearings and Dist. at noon.
3.71.30 E.		186.3	59	176 E.	36.11 N	36.00 N	9.20 W	153.8	Gib. N 88°. 19' E Dist. 204.2 miles

T R A.

TRAVERSE TABLE.

Courses corrected.	Points.	Diff.	Northing.	Southing.	Easting.	Westing.
SE by E $\frac{1}{4}$ E.	$5\frac{1}{4}$	89		38.1	80.5	
E by S $\frac{1}{2}$ E.	$7\frac{1}{2}$	100		9.8	99.5	
				47.9	180.0	

As diff. lat. = $47.9 = 8.31885$ As f. courf. $75^{\circ}.4' = 0.01492$
 .. radius = $90^{\circ} = 10,00000$.. depart. $188 = 2,25527$
 :: depart. = $180 = 2,25527$: radius $90^{\circ} = 10,00000$
 .. t. co. = $75^{\circ}.4' = 10,57412$.. dist. $186.3 = 2,27019$

Yesterd. lat. $36^{\circ}.59' N = 2391$ As rad. = $90^{\circ} = 0.00000$
 To day's d.l. $0.48 S =$.. m. d. l. = $59' = 1,77085$
 ship's lat. in $36.11 N = 2332$: t. cou. = $75^{\circ}.4' = 10,57307$
 M. D. lat. 59 .. d. long. = $221.8 = 2,34482$

N. B. The lat by acc. and that by obs. not agreeing, I correct this day's work by inspection, case 3d, page 122, which I find as follows, viz. the true course $S.71^{\circ}.30' E.$ and true diff. long. 218 miles E.

Yesterday's lon. = $12^{\circ}.58' W.$

This day's diff. lon. = $3 \quad 38 E.$

Ship's long. in $9.20 W.$

To find the Bearing and Distance of Gibraltar.

Ship's lat. $36^{\circ}.00' N = 2318$	Ship's long. $9^{\circ}.20' W.$
Gib. lat. $36.6 N = 2325$	Gibraltar's long. $5.22 W.$
p. d. lat. 6 m. d. la. 7	$3.58 W.$
	60
	238

As m. d. la. = $7 = 9,15480$ As radius = $90^{\circ} = 0.00000$
 .. radius = $90^{\circ} = 10,00000$.. p. d. lat. = $6' = 0,77815$
 :: di. lon. = $238 = 2,37658$: f. bear. $88^{\circ}.19' = 11,53201$
 .. t. bear. $88^{\circ}.19' = 11,53138$.. dist. = $204.2 = 2,31016$

The LOG BOARD.

H.	K.	F.	Courfes.	Winds.	Lee-way.	Remarks, &c. Thurf. 24th Auguft, 1786.
1	9	—	ESE.	South.	1	Strong gales and fair.
2	9	—				
3	8	6				
4	8	6				
5	8	6				
6	8	6				
7	8	4				Strong gales and 'hazy
8	8	4				
9	8	6				
10	8	4				
11	8	3				Do. weather, with
12	8	2				dryzling rain.
1	8	3				
2	8	2				
3	8	2				
4	8	—				
5	8	—				
6	8	—				
7	8	2				cleared up a little, ob-
8	8	—				ſerved C. Spartel bear-
9	8	—				ing Sby F. 3 or 4 leagu.
10	8	—				
11	8	—				
12	—	—				Came to anchor in Gib-
						raltar Bay, in 5 fathoms
						between the New & Old
						Mole, Old Mo. NNE.
						new Mole SSE.

I N S T R U C -

INSTRUCTIONS
TO
WRITE A JOURNAL,
FROM THE
LOG BOOK, or LOG BOARD.

First, mention is made of the Year, Month and Day of the Week in one Column; Day of the Month in another Column; Wind's in another Column, &c. &c. as is ruled in all Journals, which are to be purchased at most Stationers: and for a clear demonstration of Writing a Journal from a Sea Log, you will observe the following, which is done from the Log of the preceding Voyage.

A JOURNAL

OF THE

Proceedings of his Majesty's Ship the CUMBERLAND,
Robert Wilson, Esq; Commander, kept by J. Diligent,
Master, commencing the 15th of *August, 1786.*

month, year, & days.	month day.	Winds	Courses.	Dist. in mils.	Lat. in	Lon. in	Bearings and Distance at noon.
August 1786. Tuesf.	th 15	North. NbyE.					Bembridge p. NWbyW. 4 leagues.
Wedn.	th 16	North. NbyE. N $\frac{1}{2}$ E.					The Lizard NW.
Thursf.	th 17	North. NNW. NW.	S $17^{\circ}55'$ W	126	$47^{\circ}58'$ N.	$6^{\circ}14'$ W	Uthant N. $56^{\circ}19'$ E. dist. 55.8 miles.
Friday	th 18	NW. NWbW NNW.	S $17^{\circ}0'$ W	167	$45^{\circ}19'$ N.	$7^{\circ}25'$ W	C. Ortegal, S. $6^{\circ}12'$ W. d. 92.54 mi
Saturd.	th 19	NW. NNW. North.	S $57^{\circ}8'$ W	124	$44^{\circ}12'$ N.	$9^{\circ}50'$ W	C. Finisterre S. $16^{\circ}34'$ E. d. 82.23 mi
Sund.	th 20	NW. SW. WNW.	S 49° W	85	$43^{\circ}16'$ N.	$11^{\circ}20'$ W	C. St. Vinc S. $15^{\circ}43'$ E. d. 388.6 mi
Mond.	th 21	WNW. NWbW	S $18^{\circ}56'$ W	183	$40^{\circ}23'$ N.	$12^{\circ}39'$ W	C. St. Vinc S. $40^{\circ}04'$ E. d. 263 mile
Tuesfd.	d 22	WNW. WbyN.	S $4^{\circ}7'$ W	206	$36^{\circ}59'$ N.	$12^{\circ}58'$ W	C. St. Vinc N. $89^{\circ}02'$ E. d. 177.5 mi
Wedn.	d 23	SW. SSW.	S $71^{\circ}30'$ E.	186	$36^{\circ}0'$ N.	$9^{\circ}20'$ W	Gibraltar N. $88^{\circ}19'$ E. d. 204.2 mi
Thursf.	th 24	ESE.					Old Mole NNE. new Mole SE

R E M A R K S, &c.

First and middle parts moderate and fair, latter fresh gales and squally; at 3 P.M. hove short; at 5 weighed and failed; at 9 unbent the cables, and stowed the anchors at 7 A.M. Beachy-head North 7 miles.

Fresh gales and fair at 6 P.M. the Bill of Portland NW. at 4 A.M. the Start WNW $\frac{1}{2}$ W. at 5 or 6 leagues; at noon the Lizard NW.

First and latter parts brisk winds and cloudy, middle moderate and fair; at 4 P.M. the Lizard bore NE by N $\frac{1}{2}$ E. distance 5 leagues; at midnight spoke with the brig Kingston, bound to Oporto, John Wheeler, Master.

First part fresh gales and clear, middle cloudy, latter moderate and cloudy.

First and middle parts moderate and clear, latter strong breezes and cloudy; at 9 A.M. people employed in setting up the rigging.

First part strong gales and fair, middle rain, thunder, and lightning, latter fresh gales and cloudy; lay too from midnight till 9 A.M. at 9 A.M. set more sail.

These 24 hours fresh gales and fine weather; at 9 A.M. people employed in setting up the rigging.

First part strong gales and fair, middle and latter fresh gales and cloudy.

First part fresh gales and hazy, middle cloudy, latter strong gales and fair; at 8 A.M. punished John Jones with one dozen lashes for drunkenness.

First part strong gales and fair, middle rain, latter fair; at 7 A.M. Cape Spartal S by E. 3 or 4 leagues; at noon came to anchor in Gibraltar Bay in 5 fathoms.

A P P E N D I X.

A METHOD of finding the LATITUDE by DOUBLE ALTITUDES, Independent of DOUWES' New Tables.

R U L E S.

1st. Take the log. secants of the latitude by account, and the sun's declination, their sum rejecting 10 from each index will be the log ratio.

2d. To these logs add the log co. sine of the half sum, and the log sine of half the difference of the two altitudes, and also the log co. secant of the degrees and minutes in the half elapsed time, the sum rejecting 40 in the index will be the log sine of an arc.

3d. Take the difference of this arc and the half elapsed angle, and take out the complement arith. of its natural co. sine with the logarithm of that number.

4th. From this log. subtract the log. ratio, the difference will be the common log of a natural number, to which add the natural sine of the greatest altitude, their sum will be the natural sine of the meridian altitude.

5th. The latitude is then found by the Rules for meridian observations.

E X A M

December 15th, 1786, in latitude per account $51^{\circ} 30' N$. the true altitude of the sun's centre was $12^{\circ} 35'$ and $2h. 4'. 20''$, afterwards it was $11^{\circ} 20' 11''$.

December 15th, 1786, in latitude per account $51^{\circ}.30'N.$ the true altitude of the sun's centre was $12^{\circ}.35'$ and $2h.4'.20''$, afterwards it was $14^{\circ}.50'.11''$. Required the true latitude.

Latitude $51^{\circ}.30'.00''$ Sec. 0.20585
 $\odot$'s declination $23^{\circ}.19'.08$ Sec. 0.03701 }
 $14^{\circ}.50'.11''$
 $12^{\circ}.35'.00$

S. $27^{\circ}.25'.11$ } $\frac{1}{2}$ { $13^{\circ}.42'.36'' = co. f.$ 9.98744
 Diff. $2^{\circ}.15'.11$ } $\frac{1}{2}$ { $1^{\circ}.7'.35 = S.$ 8.29359

$\frac{1}{2}$ elapsed time $1h.2'.10'' = 15^{\circ}.32'.30''$ co. sec. 10.57197

Arc $7^{\circ}.10'.0 = S.$ 9.09586

$8^{\circ}.22'.30$ N. co. S. co. ar. $10.665 = 3.02796$

4

$2.78510 = 610$

True time from noon when the } $33^{\circ}.30'.$ —
 greatest altitude was taken..... }

$14^{\circ}.50'.11''$ Nat. sine 25607
 $15^{\circ}.12'N.S. = 26217$
 $90^{\circ}.00$
 74.48 S.
 23.19 S.
 51.29 N.

True latitude 51.29 N.

$0.24286 = \text{Log. ratio}$



